POWER PLANT ENGINEERING

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The World's Largest Freezer

NEW ARMOUR & CO. PLANT HAS 750-TON REFRIGERATING CAPACITY AND STORAGE SPACE FOR 42,000,000 LB. MEAT

IN ORDER to increase its already large capacity for the freezing and storing of its meat products, Armour & Co. has recently placed in operation a freezer building, which, with a normal capacity of 42,000,000 lb. of meat, is, without doubt, the largest plant of its kind in the world. Its location, in the Chicago Union Stockyards, where ground space is at a premium, rendered imperative a structure of skyscraper proportions. The building itself is of brick on a reinforced concrete covered structural steel framework, and covers a ground space 208 by 212 ft. in size. It contains nine floors above the ground, and basement, and has a total floor area of 450,000 sq. ft. and a total volume of 6,175,000 cu. ft. Its construction required approximately 5000 tons of steel, and about 3,500,000 board feet of cork were necessary to insulate the various storage rooms. Except for the first floor and a part of the second, which are used for shipping operations, the whole building is occupied by storage and freezer rooms, ice storage and the necessary heat absorbing equipment.

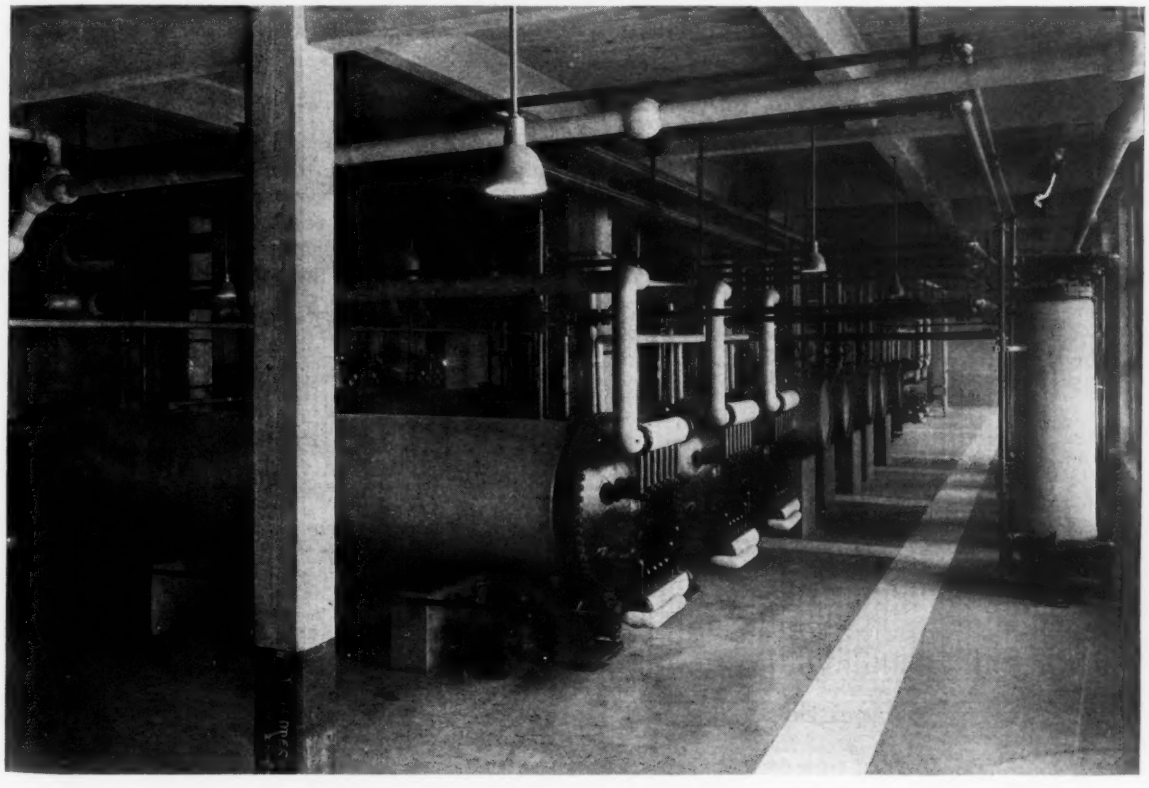


FIG. 1. VIEW IN ENGINE ROOM SHOWING THE GENERATORS, AQUA RECEIVERS AND EXCHANGERS

The refrigeration equipment necessary for the cooling of the building and the production of ice for the refrigerator cars has a normal capacity equivalent to 750 tons of ice per day and a maximum of about 1200 tons. The

engine room, containing the main units, is located on the eighth floor, with the condensers and similar equipment on the floor above.

The Engine Room

The first impression on entering the engine room is altogether favorable, due to the well-kept appearance and the practical and convenient arrangement of the various units. The general color scheme is pleasing, light gray and white prevailing. Figure 1 is a view of part of the engine room.

The equipment here located consists of five 150-ton units, three being used for cooling the building and two for the production of ice for the refrigerator cars. They are arranged in two sections, one containing the refrigerating machines at the west end of the room, and the other consisting of the ice machines at the east end. Each section is further arranged so that like units are grouped together. This layout is shown in Fig. 2. Provision is made for the installation of a sixth unit should future load conditions require.

The walls of the ninth floor are so constructed as to afford a protection against the heat of the sun, allowing, at the same time, a free circulation of air to the condensing and cooling equipment there located. The arrangement here differs from that of the engine room, in that all coils are so grouped that the units serving any one machine are together. This layout is shown in Fig. 4. The water used for cooling purposes leaves at about 80 deg. F. and is used in the wool-washing department before being discarded.

A 6-in. line from the power plant, about two blocks away, supplies steam at 135 lb. pressure for the operation of the ammonia and brine pumps. Ordinarily, the exhaust from these pumps is sufficient for the absorption machinery, but, should a greater supply be necessary, provision is made to secure exhaust steam at 5 lb. gage pressure from the main power plant.

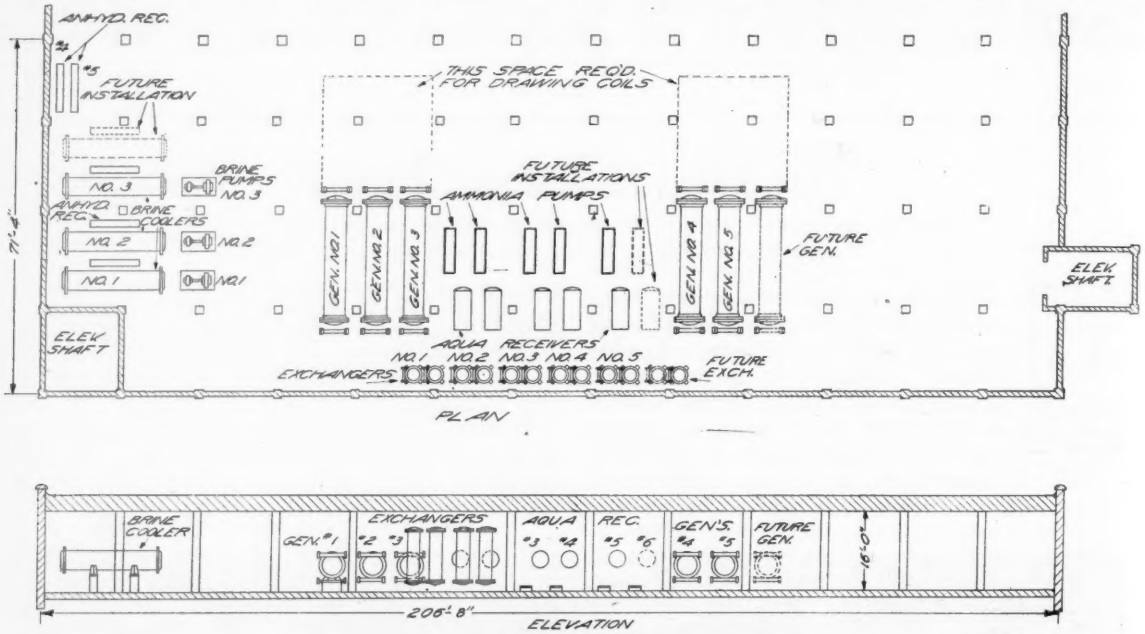


FIG. 2. PLAN OF THE ENGINE ROOM

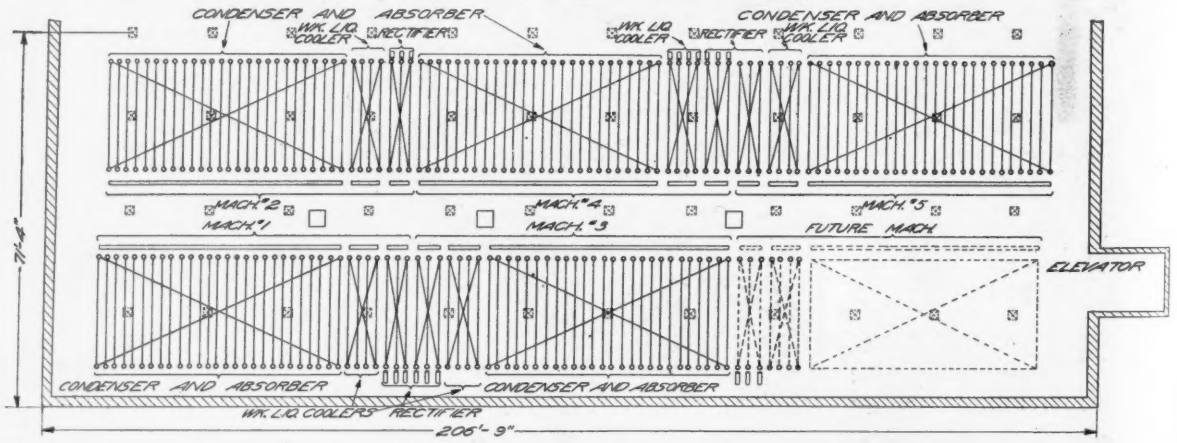


FIG. 4. PLAN VIEW OF CONDENSERS, RECTIFIERS, ABSORBERS AND WEAK LIQUOR COOLERS

The Heat-Absorbing Machinery

The generators installed each have a normal capacity of 150 tons. Exhaust steam from the pumps, at from 12 to 15 lb. pressure, is employed to distil off the ammonia gas from the strong liquor, leaving weak liquor in the bottom of the generator. Ammonia gas passes into the rectifier at a temperature of 230 deg. F. The rectifier, which is located on the ninth floor, is of the atmospheric type, cooling being on the counterflow principle. This unit consists of three stands of eight pipes, each coil being provided with end drips communicating with the generator. The object of these drips is to return to the generator any water which may have been condensed from steam entrained with the gas to the rectifier.

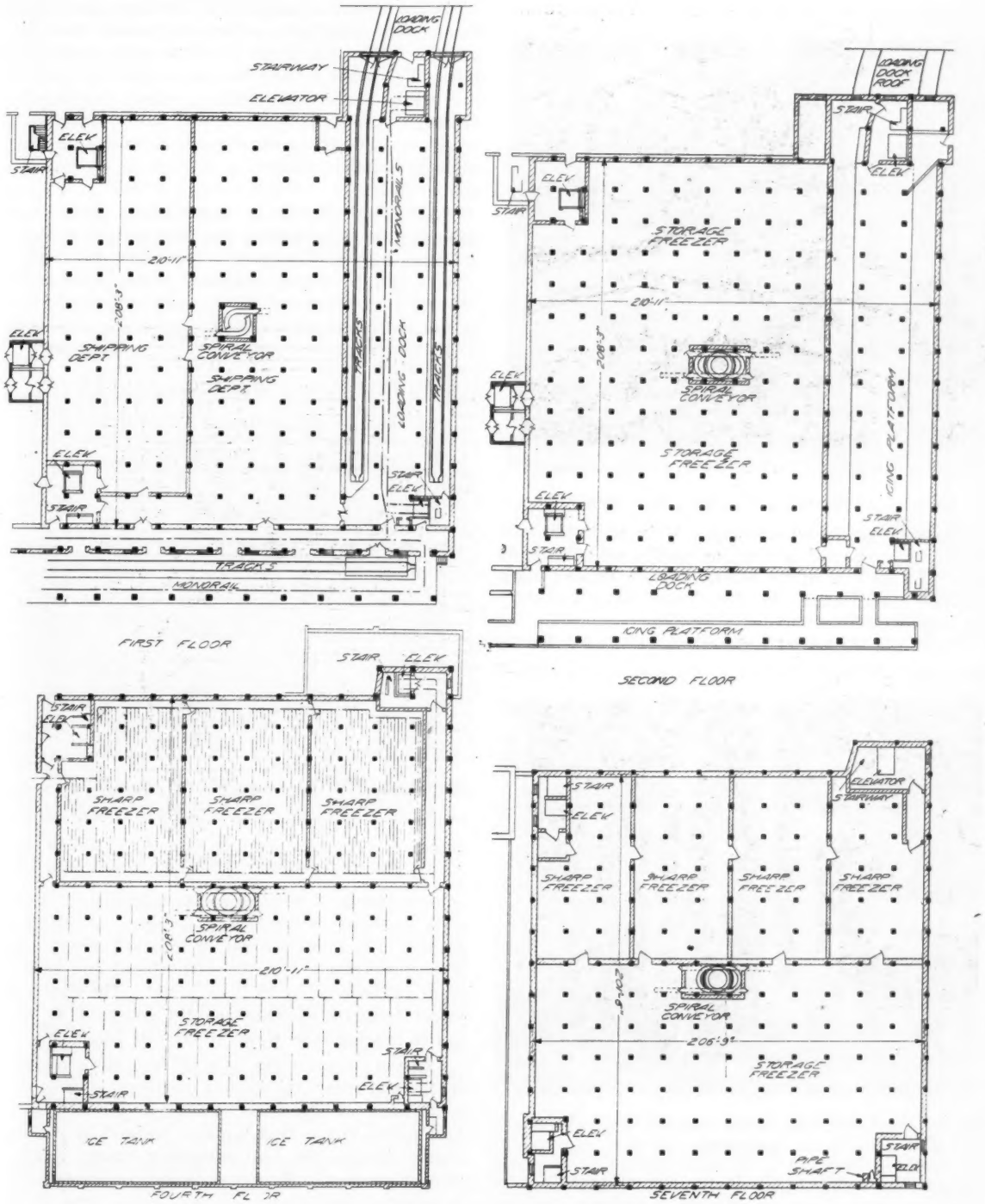


FIG. 3. A GROUP OF TYPICAL FLOOR PLANS

From the rectifiers, the gas enters the atmospheric counterflow condensers at a temperature of 70 deg. F., where it is condensed into liquid anhydrous ammonia at about 60 deg. F., passing into the liquid anhydrous receivers on the eighth floor. The condensers each consist of 26 stands, each coil six pipes in height. The anhydrous

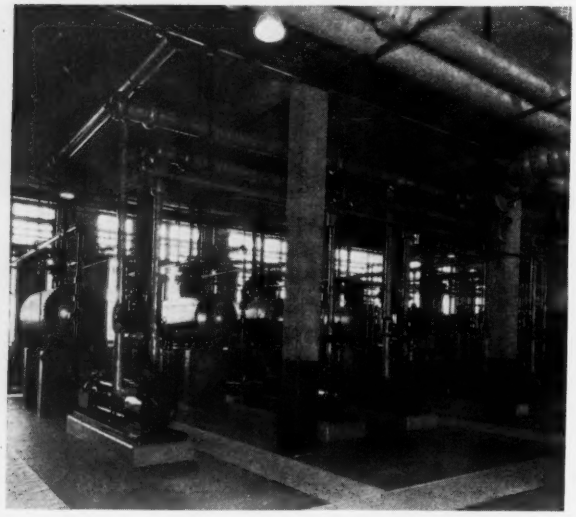


FIG. 5. AMMONIA PUMPS AND AQUA RECEIVERS

receivers are horizontal steel tanks, 16 in. in diameter by 10 ft. long, supported by cast iron cradles, set on concrete piers. In the case of the refrigerating machines, these receivers are set alongside of the brine cooler served by the machine.

The brine coolers, of which there are three, one for each refrigerating machine, are of the horizontal tubular

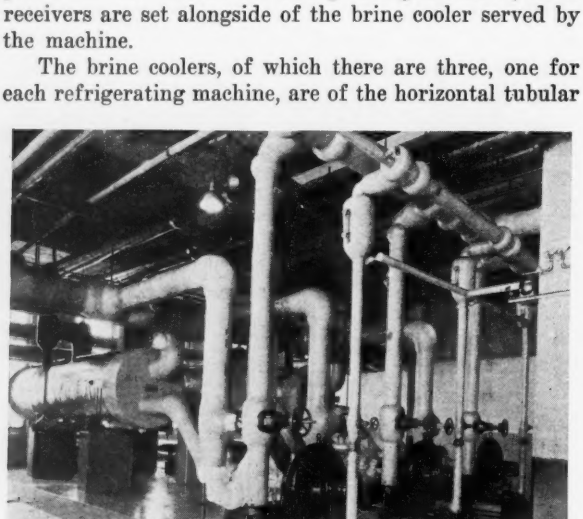


FIG. 6. BRINE PUMPS, BRINE COOLERS AND ANHYDROUS RECEIVERS

type, 45 in. in diameter by 18 ft. long, supported on tall concrete piers. Together with the anhydrous receivers, they are located at the extreme west end of the engine room. Anhydrous ammonia from the receiver is fed through expansion valves into the brine coolers, where about atmospheric pressure exists. The temperature of the gas after passing through the brine cooler is close to —20 deg. F. The absorbers on the ninth floor are of the atmospheric type, operating on the counterflow principle. They consist each of 26 stands of 12 pipes high, located under and cooled by the water from their respective condensers. The interesting feature in these absorbers is the method of mixing the ammonia gas and weak liquor. The weak liquor enters the absorbers through an annular conical jet, inside of which is the ammonia gas inlet. The result is that the ammonia gas is sucked into the weak liquor by injector action, forming aqua ammonia, or strong liquor, which passes into the aqua receivers. The latter are horizontal tanks, one to each unit, 42 in. in diameter by 8 ft. long, located in the engine room.

One 16 by 8 by 16-in. steam-driven aqua pump is provided for each unit. The five units installed are shown in Fig. 5. The speed is low, about 18 strokes per minute at 135 lb. steam pressure. This pump delivers

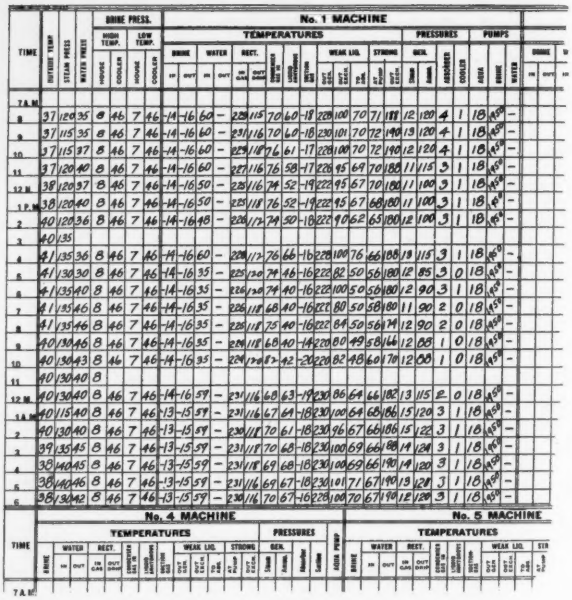


FIG. 7. ENGINE ROOM LOG SHEET

aqua ammonia, now at about 56 to 72 deg. F., from the aqua receivers to the heat exchangers, of which there are two to each unit, operating counter current in series. The exchangers are of the vertical coil and shell type, 32 in. in diameter by 10 ft. in height. The strong liquor passes from the exchanger to the generator at temperatures ranging from about 165 to 190 deg. F.

As the ammonia gas boils off from the strong liquor in the generator, the heavier portions, or weak liquor, comprising mostly water, gather at the bottom. The heat stored in the weak liquor is utilized by passing the liquor through the heat exchanger, where it gives up some of its heat to the strong liquor, and its temperature is reduced from about 230 deg. F. to from 80 to 100 deg. F. This temperature is still further reduced in the weak liquor cooler to 70 deg. F., or less, after which it enters the absorber to combine with the anhydrous ammonia. The weak liquor cooler consists of four stacks of 16 pipes and is of the counterflow atmospheric type. It

is located with the condensers, rectifiers and absorbers, on the ninth floor.

The Brine System

Brine is circulated by means of three 1000-gal. centrifugal steam turbine-driven pumps, operating at 1950 r.p.m. Flow meters are used to record the steam used and the rate of circulation of the brine.

One of the outstanding features of this plant is the low temperature it is possible to maintain in the brine system. Under present operating conditions the thermometer at the brine outlet reads —13 to —14 deg. F., and that at the outlet 2 deg. F. lower, but the plant is capable of maintaining a temperature of —20 deg. F. continuously. On account of the low temperature involved, it was necessary to use a 27 per cent calcium chloride "brine" solution, having a specific gravity of 1.250, and a freezing point of about —33 deg. F.

The whole of the brine system is at present maintained at one temperature, but, should load conditions require, it is proposed to divide it into two sections, maintaining

TEMPERATURE RECORD for 24 hours beginning 8 A. M. Mar. 9 1920

Time	1st Storage		2nd Storage	3rd Sharp					3rd Storage					4th Sharp					4th Storage				
1 hr.	1	2		1	2	3	4	5		1	2	3	4	1	2	3	4	5		1	2	3	4
Room																							
Thermometer No.	8	10	9	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	1	2	3	4	5
8 A.M.																								
9 A.M.	31		-10	-12	-12	-13	-10	4	8	-13	-12	-13	3	1	0	-11	-12	-16	-16	6	3	4		
10 "	32		-10	-11	-12	-13	-10	5	8	-13	-12	-14	3	2	0	-10	-12	-16	-16	4	3	4		
11 A.M.	32		-9	-10	-12	-13	-10	4	8	-12	-12	-14	4	0	0	-11	-12	-16	-16	6	3	4		
12 M.																								
1 P.M.	33		-9	-10	-12	-13	-10	5	9	-13	-12	-14	3	1	2	-10	-11	-16	-15	6	3	4		
2 P.M.	33		-9	-10	-12	-13	-10	5	9	-13	-12	-14	3	1	1	-11	-11	-16	-16	6	3	4		
3 P.M.	33		-9	-11	-12	-13	-10	4	9	-13	-13	-15	3	1	1	-12	-12	-16	-16	6	3	4		
4 P.M.																								
5 P.M.	33		-9	-12	-13	-13	-10	4	9	-13	-12	-15	3	1	1	-12	-12	-16	-16	6	3	4		
6 P.M.	33		-9	-12	-13	-13	-10	4	8	-13	-12	-15	3	1	0	-12	-12	-16	-16	6	3	4		
7 P.M.	33		-9	-12	-13	-13	-10	4	8	-13	-12	-15	3	1	0	-12	-12	-16	-16	6	3	4		

Time	5th Storage				7th Sharp					7th Storage				5th Sharp					5th Storage					REMARKS
1 hr.	1	2	3	4	1	2	3	4	5	6	1	2	3	1	2	3	4	5	1	2	3	4	5	
Room	EAST		WEST											EAST		WEST								
Thermometer No.	1	2	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	1	2	3	4	5	
8 A.M.																								
9 A.M.	0	7	8		-16	-18	-17	-12	4	5	10			-3	-3	1	0							
10 "	0	7	8		-16	-16	-17	-12	4	5	10			-3	-3	1	0							
11 A.M.	0	7	8		-15	-17	-16	-12	3	5	10			-3	-3	1	0							
12 M.																								
1 P.M.	0	7	10		-15	-17	-16	-12	3	5	10			-2	-3	1	0							
2 P.M.			6	9	-13	-17	-17	-12	3	5	10			-2	-3	1	0							
3 P.M.			6	8	-16	-16	-17	-12	3	5	10			-2	-3	1	0							
4 P.M.																								
5 P.M.	1	-1	6	8	-16	-18	-17	-12	3	4	10			-3	-3	1	0							
6 P.M.	0	-1	6	8	-16	-18	-17	-12	3	4	10			-3	-3	1	0							
6 A.M.	0	-1	6	8	-16	-16	-17	-12	3	4	10			-3	-3	1	0							

FIG. 8. TEMPERATURE RECORD OF FREEZING AND STORAGE ROOMS

one at about —20 deg. F. for the sharp freezers, and the other at 0 deg. F. for the cold storage rooms.

The Freezer and Storage Rooms

Several of the floors are divided into two sections, known as the sharp freezers and the storage rooms. The sharp freezers are further divided into a number of smaller rooms. The method of procedure is to take the meat from the cooler at a temperature of 36 to 38 deg. F., where it was held for at least 48 hr., and place it in the sharp freezers, where it remains for 72 hr. at a temperature of from —10 to —20 deg. F. The meat is then transferred to the storage rooms, where temperatures from 0 to 12 deg. F. prevail. The accompanying temperature record, Fig. 8, gives typical operating temperatures of both sharp freezers and storage rooms.

In the sharp freezers, both overhead and side piping are employed, averaging 1 lin. ft. of 2-in. pipe to 5 cu. ft. of space. In the storage rooms, overhead piping only is employed, and the average ratio is 1 lin. ft. of 2-in. pipe to 7 cu. ft. of space. All storage rooms are thoroughly insulated by air space and cork board. A typical outer wall consists of 13 in. of brick, followed by a layer of hollow tile, 6 in. of cork, and an inner finish of a ¾-in. coat of cement plaster. Meat is brought to the various floors by means of four electric freight elevators located in the four corners of the building, and trucked to the desired location. Delivery in the direction of the shipping floor is by means of a spiral chute located in the center of the building.

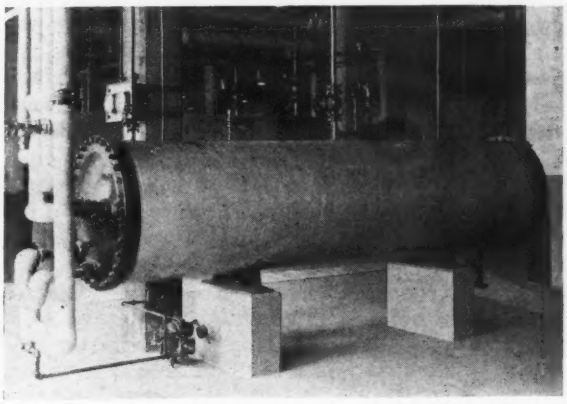


FIG. 9. THE ECONOMIZER

The two absorption machines used for the production of ice for the refrigerator cars are identical with those used for cooling the building with the exception of the brine system. Direct expansion is employed in the freezing tanks on the fourth floor of an annex to the main building, where city water is frozen into opaque ice. The ice is delivered by means of a chute to the ice storage on the second floor. When required for icing

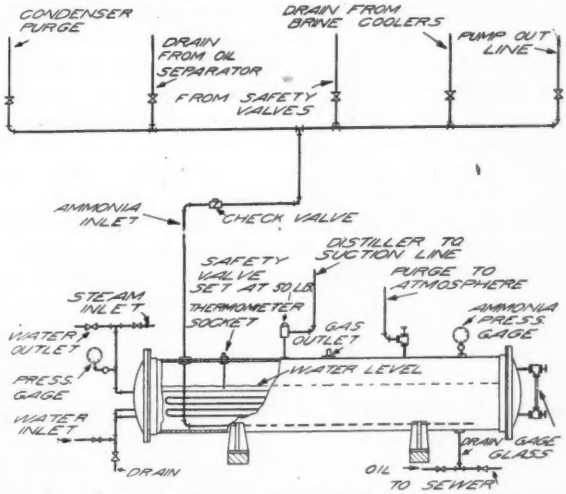


FIG. 10. SECTION THROUGH ECONOMIZERS AND CONNECTIONS

refrigerator cars the ice is passed through a crusher and broken up into the equivalent of 2½-in. cubes, or smaller. It is then carried to the cars by means of monorail equipment installed on a balcony on the second floor, immediately over the loading docks. Docking space is provided on the first floor for icing and loading 33 cars at one time.

The Economizer

One of the most interesting features in connection

with the plant is the method of reducing to an absolute minimum the loss of ammonia when purging or pumping out various parts of the system. This is accomplished by means of an economizer, Fig. 9. In the external appearance and general features of construction, this economizer is somewhat similar to the generator. In operation, however, it is alternately an absorber and a still. The ends of the coil are each provided with two connections, one for water, and the other for steam, as shown in Fig. 10. The method of operation is to fill the shell with water to cover the coils, and purge the different parts of the plant through this water by means of the perforated pipe shown in the bottom of the economizer. Any ammonia gas which may be entrained with the foul gases will be absorbed by the water, the foul gases rising to the top of the shell. Foul gas collected in the economizer is purged by opening the air valve, no ammonia being present in the vent. The heat of the absorption is carried away by water circulating through the pipe coils. A safety valve, set for 50 lb., is provided to relieve excess pressure, discharging into the suction line.

When the liquor has become somewhat concentrated, steam is substituted for the water in the coils and the ammonia is re-distilled back into the system. By the use of the economizer any part of the system can be pumped out without the necessity of shutting down the whole machine.

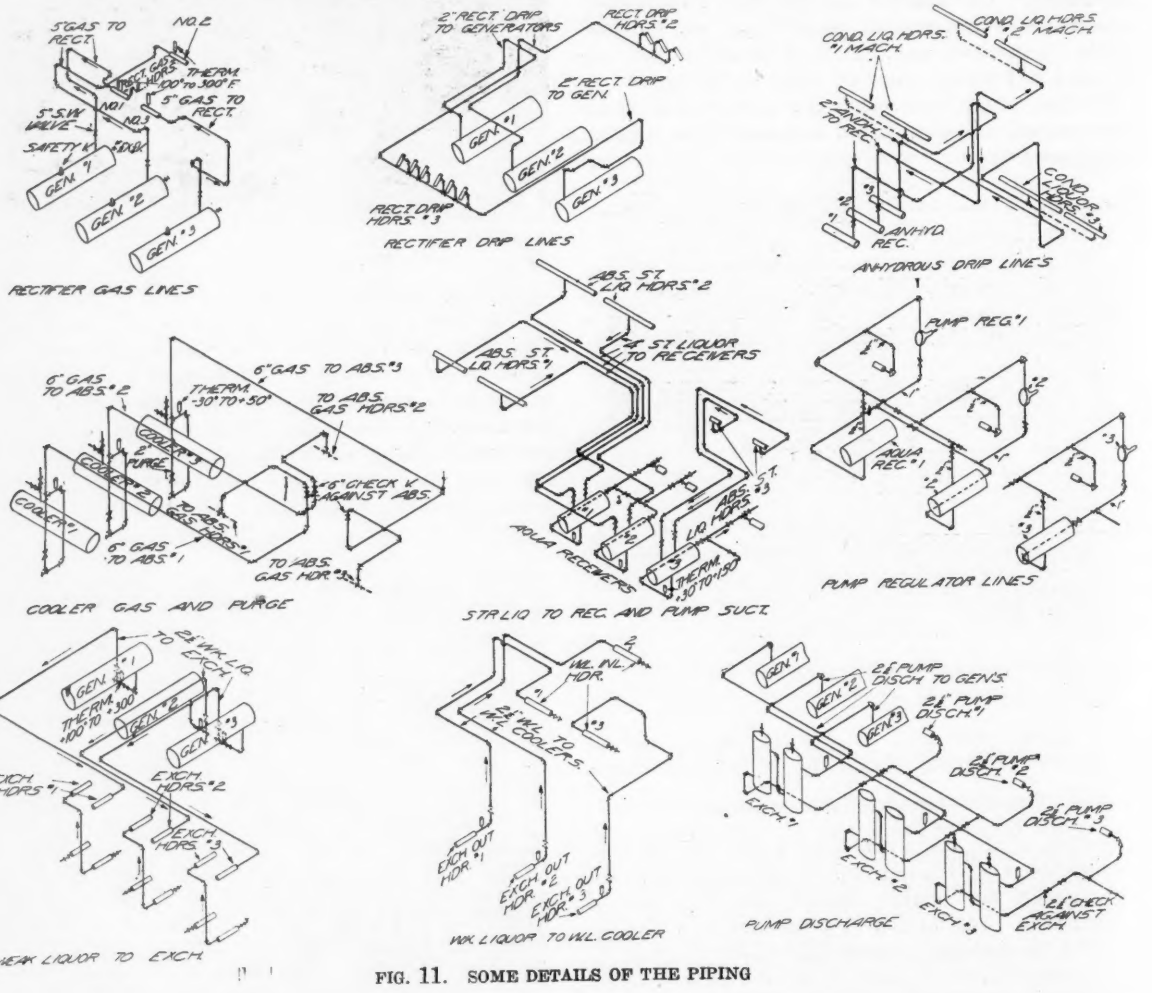


FIG. 11. SOME DETAILS OF THE PIPING

The Importance of Definitions to the Industrial Engineer

INDUSTRIAL engineering's chief tool, said the speaker, in a recent address, is the language with which those who concern themselves with this subject converse. The greatest effectiveness is gained when the tool is standardized.

When one uses the term "functional management," those to whom he speaks "ought to begin thinking in the same way that the speaker is thinking. . . . Nothing would tend more to spread the results of the practical application of the principles of industrial engineering than a working kit of definitions applicable to his profession."

A testing department without standards would be unthinkable in the shop. First and foremost among the standards needed in industrial engineering are standard definitions and standard methods of preparing reports. —L. Galloway, at the National Convention, Society of Industrial Engineers.

Power Production and Lower Prices

A Consideration of the Financial Side of Power Plant Engineering. By L. W. Alwyn-Schmidt

DURING the war, conservation policies were applied principally in the direction of saving material. Price did not enter into consideration; in fact, it was thought a wise policy to add to cost if the cost-increase would bring about a reduction in the consumption of material. The industry had to go along in the face of a severe shortage of many important raw materials. There was then as much virtue in making go a little further a boiler equipment that should have been replaced by a new one as in preserving a ton of coal or two. But the practice, laudable as it was during the war, has brought in its wake many undesirable features that now begin to be obstacles in the way of economic readjustment. The world, having been able to go along for many months with a largely reduced supply of coal, seems to assume that it can continue permanently to operate its industries upon the same coal consumption as it did during the war. Equipment introduced for the purpose of saving coal or increasing the efficiency of the power has proved expensive in many other ways, and now affects the cost of production. Methods that have been economical during the war seem to prove wasteful now. And all the while the world cries out for cheaper prices, demands more and more energetically a reform of our industrial methods so as to bring about more normal conditions than those existing at the present time.

The demand is one that cannot be well neglected. Signs appear that indicate a serious disturbance of our industrial life if a remedy is not found for the prevailing evil of high prices and excessive cost of living. Retailers in many sections of the country will tell you that they have not had a good spring season and that the public is buying less than it purchased in the past. Retailers, in consequence, begin to get disheartened and reduce their own purchases, and there is every danger that the nervous condition in the retail trade will spread to the wholesale distributors until it finally reaches the industry itself. Fewer orders means less work for labor, and, with partial unemployment looming before us, there is no benefit in high wages. All the while the public is only too ready to buy. The middle class, which is the most powerful purchasing stratum of our population, is ready to give big orders if it can get things at a reasonable price. Men have gone along these years with an under supply of clothes, fewer shoes have been sold, and no matter of argument can explain away the fact that the demand has fallen below normal in many of our best selling commodities. Prices, therefore, will have to come down to bring new customers into the market. All branches of industrial activity in this country must combine to that end and the power house is involved as much as the shop proper or the office staff. The high cost of living is not a single phenomenon, but the result of a great many minor factors that all act together in their price raising effort. Some of these factors have their seat in the power house and their removal will be necessary, along with all the others that obstruct our return to normal price conditions.

During 1914 American industry had an expenditure for fuel and rent of power of $666,000,000. To this must be added the interest on an investment in power house equipment and private electrical generation equipment of a value of $1,000,000,000 at least, and wages and salaries amounting to $600,000,000 approximately. Taking the interest charge at the rate of 5 per cent and a charge for depreciation of equipment of 8 per cent a year, the total expenditure for power generation in 1914 will have been $2,566,000,000, or a little more than 10 per cent of the total value of our national industrial production. Estimates differ much as to the growth of American industries during the war and pending completion of the industrial census it is difficult to settle upon a reliable figure. Experts who have tackled the question, however, seem to be of opinion that in value, at least, the national production has trebled since 1914. Accepting these figures as substantially correct and assuming that no change has taken place in the relation of cost of power to cost of production, it is not at all unlikely that the American nation has spent $7,500,000,000 a year for power production alone during the last few years. This is an enormous amount, and a saving of only one-tenth of it would bring about a material reduction in the cost of production.

Power House Prime Factor in National Industrial Activity

If such a saving could be obtained right in the power house where the primary energy is manufactured for all the national industries, it would be even of more importance to the price constellation than in the case of savings which are made in the manufacturing process proper. All cost increase in the world derives its life from two distinct causes. One, and this is by far the larger factor, is the cost of the energy that is applied to the making of the article, meaning labor and power; the other is the profit of the producer, commonly called the earnings of capital. It is said that the first two absorb more than 90 per cent of all increase in cost. Let us take the example of a ton of iron ore as it comes from the mine. Whatever may be its cost, 10 per cent of it has been consumed by the power house aiding in the mining of the ore. The ore goes to the mill, and later to the furnace. When it enters the market in the form of pig iron, a new 10 per cent has been added for power needed in the mill and the furnace. So the process continues until the knife appears upon the table or the machine tool in the machine shop. But here is an important fact. Ten per cent of 100 is 10, and 10 per cent of 99 is only 9.9. Also profits are invariably figured upon the cost price. A factory will add, say, 25 per cent to the cost of production and make this its sale price. The profit figure gets higher with every raise in the cost of production, even if the percentage remains the same.

Attacking the problem of high prices from the power house, therefore, is not so hopeless an enterprise. It promises, in fact, better results than an attack upon the cost of labor. In the first case, we deal with a tech-

nical problem, pure and simple. In the second enters the human element. Technical problems will yield to treatment where the human mind rejects advice. There is no doubt that, in time, wages will have to come down; but, before this point is reached in economical development, an attempt should be made to correct the situation from all those angles that can be handled more easily.

American power houses are now excellently equipped for the purpose of saving material. The question now is, what can be done to use the same equipment for the just as important purpose of reducing cost of power production? It may not have occurred to all power house men, but there is, unfortunately, such a thing as being over equipped. Take, for instance, a power unit producing a certain quantity of energy at a certain quantity of coal consumption. Install in this power house a series of supplementary units intended to reduce the consumption of coal, and it depends entirely on the cost of the new equipment whether the installation is economical in the financial sense, however advisable it may have been as to the reduction in coal consumption. The economic usefulness depends entirely on whether the interest and maintenance charges of the additional equipment remain in bearing to the resulting fuel saving or gain in efficiency.

In the rush produced by the desire to assist the nation's coal conservation policies, and probably induced by the high cost of coal, much equipment has been introduced into our power houses that may cost more to operate than is justified by the savings of coal or the increase of efficiency of the power equipment. As long as coal prices remain high, our manufacturers will not have to regret their generosity during the war. If the price of coal, however, should come down, and this is an aim now worked for, it is likely that the equipment will no longer fulfill the expectations that had been connected with its purchase, will, in fact, be a hindrance to the economic operation of the power house.

Power house engineers, therefore, will do well to examine their main and supplementary equipment from that point of view. Nearly all power house equipment that was purchased during the war was bought at the considerably higher rates prevailing during that time. Cost increases have varied from between 100 and 200 per cent. The interest charge and maintenance cost upon $100 worth of equipment is approximately $13. It is exactly three times as much if the same unit has been bought at so-called war prices. In the case of equipment costing $20,000 at pre-war prices, the difference amounts to $2600 a year, which adds considerably to the cost of power production of that particular unit. This does not consider the higher depreciation of all industrial equipment during the war, caused by working longer hours and the somewhat inferior quality of most of the industrial equipment supplied during the war. It is clear, however, that the manufacturer who owns a power installation bought before the war is situated better in respect to power production cost than the man who bought his equipment during the war. His position will be still worse if the cost of power equipment declines again in the future and if much new equipment comes into the market at prices ranging 25 per cent and more below present levels.

Power Engineers Best Judge of Own Equipment

Power engineers, unfortunately, do not hold always that position of entire trust that should belong to the man who is in charge of all the supply of live force that flows to the machines of the factory. But here is a case where the engineers will have to take the bit between their teeth and get away with the carriage, in spite of the counting house. The facts of the situation must be pointed out to the accountants so that they will realize the bitter truth. If the power engineers fail to do their duty in this respect they do not harm only the enterprise they work for, but they may be blamed later for producing power at an excessive cost.

The fact is, the power house that recognizes the present danger and does not act upon this realization is permitting the firm to squander earnings that really have not been made. This is particularly true in the case of incorporated enterprises where the shareholders claim their profits. Just imagine the case of such a million-dollar concern with a power house costing $100,000 during the war. Quite apart from the actual running expenses, this power house equipment costs the firm, upon its own showing, a matter of $13,000 every year in maintenance and interest upon capital. Let the same concern compete against a similar enterprise that has bought its power house equipment during the time when power equipment cost $50,000, and the competing firm is able to produce power at exactly $6500 less than the first firm. Every unit of production is loaded with a share of that $6500. Today the same firm distributes still, say, a 10 per cent dividend. If it continues the present practice, it may find, in future, that it produces at an uncompetitive price, and may have to reduce its dividend payment accordingly. Why not provide now for that eventuality and safeguard the productive organization of the concern and, at the same time, bring down manufacturing cost?

I know accountants will not like the proposition, neither will it be appreciated, at the time of writing, by the board of directors of any concern where it is made. Nevertheless, the war cost of the power house equipment should be written off until a sum is reached that conforms approximately with the cost of the equipment as it stood before the war. The money that is appropriated for that purpose should be taken from the running profits of the next 3 yr. and placed in reserve, to be used either for the re-purchase of the power house equipment when renewal becomes necessary, or it may be divided later as profit when prices have become more normal again; but it would immediately help to reduce the cost of production in that particular factory at a point where the application of cost saving methods appears to be most effective.

I know there will be men who think the cure in this case worse than the disease; but against those must be held, first, that it has been employed by several of the biggest American industrial enterprises, all through the war or at least since the start of the present rise of the cost of equipment, and second, that its application is recommended only in the case of power house equipment. The effect of power house cost upon cost of production is so fundamental as to require the most energetic means for a salvation of the situation. All other equipment

cost is subject to the productive activity of the firm. You may have a machine equipment costing $100,000 and employ only part of it and the loss is not so heavy as it would be in the case of power house equipment. Whatever is the rate of employment of the shop equipment of a firm, the employment of the power house remains the same. There is no such a thing as partial rest of the power house equipment. In fact, partial employment only tends to increase the cost.

The duty of the power house staff to the firm, therefore, seems to be clear. It demands an investigation of the power house equipment, old and new, and a study of its present effect upon the cost of power production in the factory. If part of the equipment is found to be too expensive steps should be taken to neutralize the effect of this particular unit upon the rest of the power house installation. This can be done (1) by improving the usefulness of the unit; (2) by excluding it entirely from the scheme of production; or (3) by writing off the financial load. The first way of course is the best, but is doubtful in its results. An equipment unit is either in good condition or it is not. But there may be cases where the unit is not employed to best advantage. They will be rare in any well organized power house. The second recommendation will rarely be accepted because of the financial loss involved in its execution. Any supplementary unit of equipment that has been bought during the war for one or the other reason has its special uses and the power house should derive certain advantages from its operation. It may have been bought at too high a cost; but when selling the unit, there is not only the financial loss to be considered, but the help of the equipment unit in the power house. So the best in every instance will be the last proposition, that of writing off the cost of the equipment or at least a reasonable part of it as special over expenditure and let the unit stay where it is. In following this practice, the overhead expenses are reduced materially and a wedge is driven in the phalanx of the high cost of production. That the saving is not already very large should not detain from making the attempt. We can not expect the present high cost of production to come down with a crash. In fact, it is just the crash that must be avoided at any cost. So an occasional dollar saved here and another there must be the start of the movement. But the saving must be made with an end in view; the more vital the spot where it is made, the better is the outlook for success.

An Interesting Installation of Coal-Handling Equipment

TOTAL STORAGE CAPACITY OF 100,000 TONS WITH CONVEYORS TO HANDLE MAXIMUM OF 600 TONS PER HOUR FROM STORAGE TO BUNKERS

ONE OF the most interesting of the newer installations of coal-handling equipment is that at the United States War Department's Old Hickory Smokeless Powder Plant, at Nashville, Tenn. The maximum storage capacity is 100,000 tons. The coal is handled by means of a combination of apron feeders, belt conveyors, and specially built locomotive cranes. All equipment is installed in duplicate, to eliminate delay, due to accidents to any of the units.

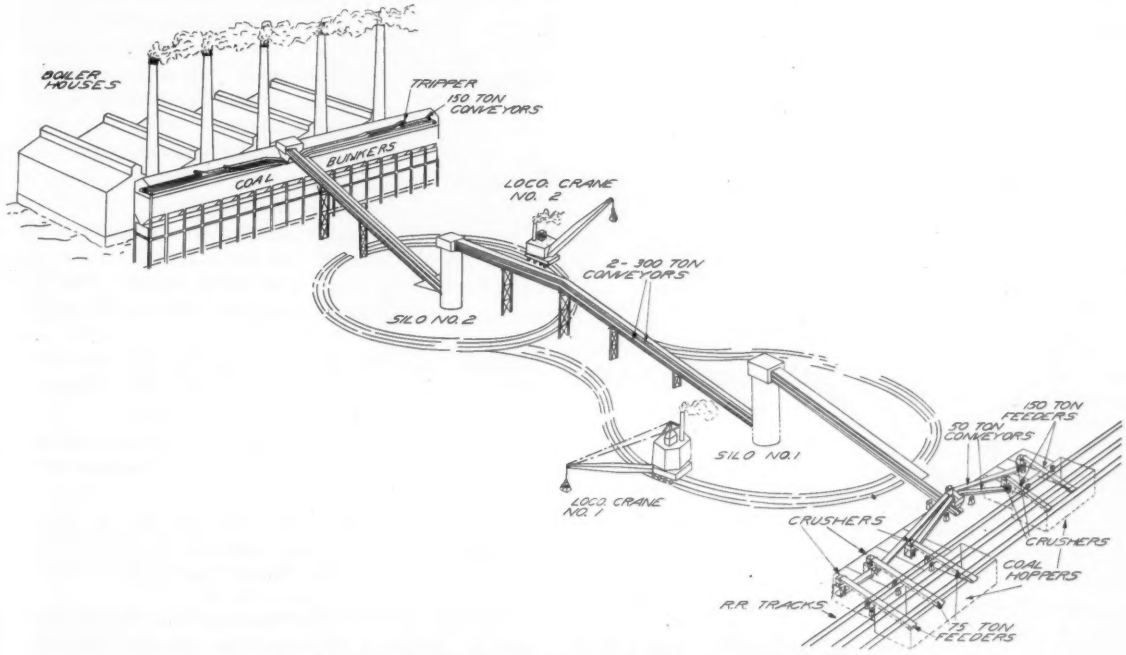


FIG. 1. PERSPECTIVE VIEW OF COAL-HANDLING EQUIPMENT

Coal is received on a three-track siding off the main railroad line, under which are located the two receiving hoppers, so placed that each one serves two tracks. The coal is removed from these hoppers by means of five apron feeders, 42 in. wide by 12 in. pitch, and delivered to five 36 by 36-in. coal crushers, located one at the head of each feeder. Each of the two conveyors located in

the smaller pit has a capacity of 150 tons of mine run coal per hour, while the three located in the larger pit have a unit capacity of 75 tons per hour.

From the crushers, the coal is carried by means of four 24-in. electrically-driven belt conveyors, all discharging into one hopper, at the foot of a pair of 24-in. belt conveyors which convey the coal a distance of 175 ft. to Silo No. 1. These belts are arranged side by side, with individual motors and controls, and each one is capable of handling 300 tons of coal per hour.

The silos form one of the outstanding features of the plant. The walls are of reinforced concrete, and each silo is surmounted by a square chamber containing a receiving hopper, communicating with the outside of

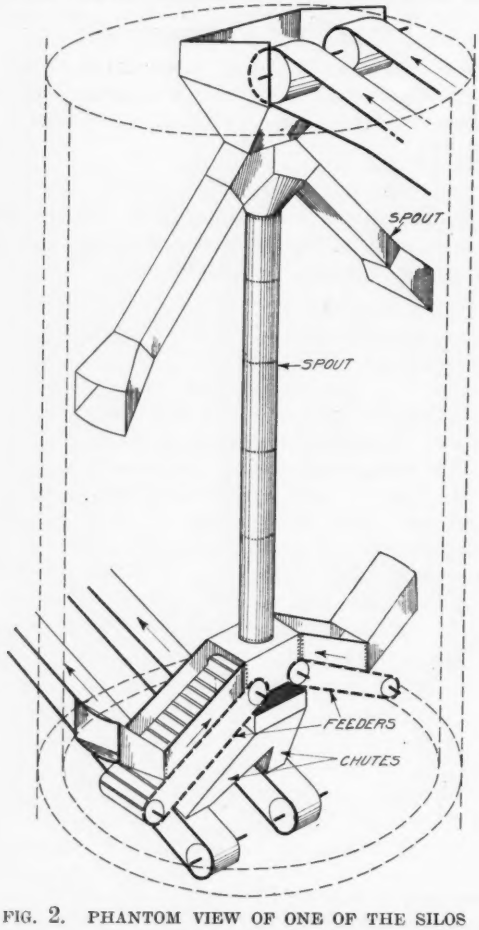


FIG. 2. PHANTOM VIEW OF ONE OF THE SILOS

the tower by means of two inclined spouts, and having a vertical spout terminating in chutes which discharge the coal onto belts which carry it to Silo No. 2. A phantom view of a silo is given in Fig. 2.

The bottom of the hopper is supplied with doors, enabling coal to be put into storage or passed on to the boiler room at will. When coal is to be stored, the central spout is closed and the coal is discharged through the inclined spouts to the surrounding piles. As the coal accumulates around the silo, it is distributed by means of a locomotive crane. Two specially built cranes are provided for this service. These cranes are mounted on four swivel trucks, which operate on a four-rail track, formed roughly in the shape of a figure eight, as shown in Fig. 1. Each crane is provided with a 110-ft. boom and can thus cover a ground area 220 ft. in diameter without traveling.

Coal going to the coal bunkers or Silo No. 2 passes through the vertical spout to one or both of two 24-in. belt conveyors which carry it at the rate of 300 tons per hour per belt to the second silo 400 ft. distant. Silo No. 2 is identical with Silo No. 1, and the conveyors from this point to the coal bunkers are similar to those which have been described, but are only 275 ft. long.

A distributing hopper, located over the coal bunkers, receives coal from the main conveyors and delivers to any of four belt conveyors, which discharge at any desired point in the bunkers by means of trippers.

In reclaiming coal, the locomotive cranes operate in a reverse direction to that of storing. Coal is piled up around a silo, and then passes downward through two reclaiming spouts to reclaiming apron feeders, which discharge through chutes to the belt or belts which carry it to the coal bunkers or the second silo.

Study

THERE MUST BE a purpose in study, as a path through the woods; without that one wanders aimlessly.

Again, to study efficiently one must be interested; without that it is drudgery. Without appetite eating benefits you little, and without interest study is time lost.

Another essential in study is lively attention. A thing vividly impressed upon you stays with you. If your attention wanders, shut the book, do something else, and come back to it later.

But perhaps the most important element in study is repetition. That is the secret of mastery. Never mind; if you have forgotten look it up again.

Another essential matter is to understand all you read. Do not assume. Do not take things for granted. Challenge every fact. Use the dictionary, the encyclopedia, the teacher. Investigate. Ask questions. Know. Do not guess.

Study regularly whether you feel like it or not. The feeling will come in the grooves of habit. There can be no strong mental fiber without discipline.

And when the habit of study is formed, and pursued diligently, you will find it to be one of the most unalloyed joys of existence.

Most persons who have led any sort of intellectual life can truly say: "My happiest hours have been my hours of study."—DR. FRANK CRANE, in Forbes.

ACTING DIRECTOR COTTRELL, of the Bureau of Mines, recently issued a statement on gasoline shortage. He said, in part: "While the gasoline situation appears to be in an acute state in California, where there was only two weeks' supply in February, this is not now true in any other parts of the country. It is undoubtedly true, however, that, due to the much greater increase in the number of automobiles in use today, compared with the increase in both gasoline and crude oil, from which gasoline is derived, it is possible that this shortage may become serious before the summer of 1920 is over. Production of gasoline in February, 1920, was about 11 per cent more than in the corresponding month in 1919, but the number of automobiles and trucks in use was about 25 per cent greater."

STAUNTON B. PECK

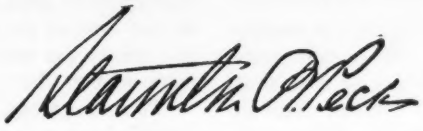
DEVELOPED LABOR-SAVING DEVICES FOR ELEVATING AND CONVEYING. NOW AN ABLE ENGINEERING EXECUTIVE. BY B. A. GAYMAN

MR. PECK is reticent in regard to his boyhood. He admits having been born—in New York, 1864—but refuses to divulge his early peccadillos and experiences. We may guess, however, from his later work, that he devised pulley arrangements that worked for filling the woodbox and coalhod, and for carrying out the ashes on the return trip. Also, it is a safe guess that he worked out some labor-saving system of splitting wood, so that chores would not interfere with his fishing and swimming excursions in the days of real sport.

When serious work began, he attended St. Paul's preparatory school and fitted for Columbia University, from which he graduated in 1886, with degrees of E. M. and C. E.

From that time he has been developing conveying and storage systems, looking always to releasing human muscles from strenuous labor.

As often happens in respect to the man with a creative brain, especially if he be an engineer, the products and results of his work are widely used and appreciated by his fellow men, but the man himself is not so well known.



For 35 yr. Mr. Peck has been serving his fellow engineers and humanity all the time in the same line of effort and with the same firm. Engaged as a draftsman with Burr & Dodge, at $12 a week, by the late James Mapes Dodge, he had the great advantage of early association with one of the country's greatest inventors and engineering geniuses. And Mr. Dodge, appreciating the ability of his helper, gave him rapid promotion.

Mr. Peck's experience covered every phase of the Link-Belt Co.'s business, from estimating and selling the product to collecting the money after erection was completed; and interesting are the stories he tells of those days of pioneering in the new fields of elevating, conveying and storing coal.

Great progress was made, and Mr. Peck, in co-operation with Mr. Dodge and other associates, developed various types of machinery, the most important being, probably, the Dodge system of storing and reclaiming anthracite coal. Many of the older readers will recall seeing these big piles stored convenient to eastern industrial centers.

Continuous systems were also a part of his work, the first continuous foundry system being developed and installed by him for the Westinghouse Air Brake Co.

The Burr & Dodge organization grew apace, finally absorbing the New York branch of the Link-Belt Machinery Co. and being known as the Link-Belt Engineering Co., largely as a result of Mr. Peck's devices and organizing ability. One of the devices developed, the "Peck Carrier," has become known as a type, much as the name "Kodak" is used to denote a camera.

In 1891, Mr. Peck was called to Chicago as chief engineer of the plant, and, after consolidation of the various interests, became vice-president of the Link-Belt Co., first in charge of the Chicago works and later in charge of eastern activities. He is now senior vice-president and resident general manager of the plant in Philadelphia, being the oldest engineer in length of service engaged in the construction of elevating and conveying systems.

He has always loved outdoor pastimes. In former days, this meant bicycling, running and rowing. Now he has settled to the more demure pastimes of golf and motoring. His host of friends and the genuine loyalty of every employe have been deservedly won by his fair treatment of everyone and his gentlemanly conduct under even the most trying circumstances.

There is no "Private" on his office door. Anybody can see him at any time and be sure of a sympathetic hearing. The youngest employe is as welcome at all times as the most important executive.

And so is the world made a better place to live in by such men as Staunton B. Peck.

In the old days, a laborer was introduced to a wheelbarrow, pick and shovel and a pile of material; his instructions were "Hop to it." Mr. Peck's work has been to take the drudgery out of such tasks. And the work of elevating and moving material, now quickly and smoothly accomplished by his devices, could not possibly be accomplished in the present magnitude by the old methods. From place to place the loads move in orderly procession, while man stands by to direct their course, to march them or halt them, as desired.

Setting Locomotive Slide Valves

By Geo. W. Childs

FOR regular practice, the right-hand crank leads, the inside eccentrics are connected to the upper knuckles of reverse-link for forward motion, the parts being stamped, Right (R 1) and Left (L 1), and the outside eccentrics are connected to lower knuckles for backward motion, and stamped R 2 and L 2.

The motion imparted to the rock shaft by the eccentric is influenced by the position of the reverse-link. When this is dropped below the central position, as

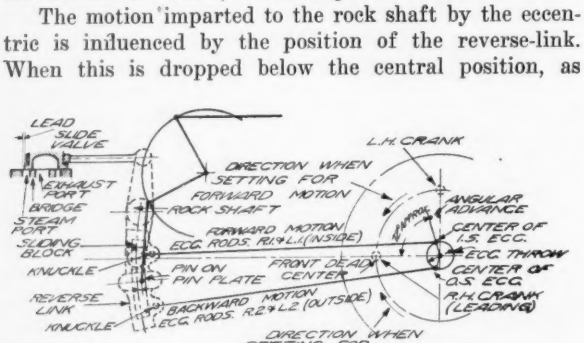


DIAGRAM OF LOCOMOTIVE TYPE OF STEVENSON VALVE GEAR

shown in diagram, then the forward motion eccentric is principally operative and is said to be the controlling eccentric. Similarly, when link is raised, the backward motion is the controlling eccentric.

On locomotives the direction of motion is usually reversed by means of a rock shaft. The valve motion is then termed "indirect-acting." When no rock shaft is used, it is called "direct-acting." When indirect-acting, the controlling eccentric always follows the crankpin in the direction of its motion, and is about 72 deg. behind it. When direct acting, the controlling eccentric precedes it by the same amount.

To set valves for indirect motion, as in diagram, first find position corresponding to dead center of crankpin front and back as follows:

Revolve the wheel until crosshead is near the end of the stroke, scribe its position on guide, and also tram point on circumference of wheel to any convenient point of frame, then continue to revolve wheel until crosshead completes stroke and returns to original position. Now tram from same point on frame to new position on the circumference of the wheel. Bisect the arc between the two points on wheel and revolve latter back until point so found trams with point on frame. The crankin will then be on dead-center.

After placing crankpin on front dead-center, clamp forward-motion eccentric above, and back down eccentric below center of wheel, each approximately 72 deg. from crankpin. Then temporarily clamp eccentric rods and get position of reverse lever on catch for full travel forward and backward, allowing at least 5/16 in. clearance between end of link and sliding block. Then, for full travel, square the valves; i. e., equalize travel front and back by adjusting eccentric rods and get desired lead by adjusting eccentrics. Now place the piston on half-stroke position and equalize cutoff for that position by adjusting the pin-plate.

For indirect acting motion, move the pin back if cutoff is latest in back end of travel, and vice versa.

If the last adjustment disturbs the symmetry for the gear, then readjust the eccentric and rods as at first and go through the whole process again. This should be repeated until the port openings front and back are as nearly equal as possible for all positions of the reverse-link. The eccentric should then be permanently keyed to axle.

Remember always to revolve the wheel as when running forward when setting valve for forward motion and vice versa.

Care should be taken to have the axle in its normal vertical position when valves are being set, as any variation disturbs the symmetry of motion and is especially noticeable with short eccentric rods. From time to time, as the engine settles, or accumulates lost motion, the valves should be reset, and the eccentrics held in position by off-set keys.

Record Run of Large Turbine

OPERATING without a shutdown for a period of 84 days, 11 hr., 36 min., the 45,000-kw. turbine-generator at the power plant of the Narragansett Electric Lighting Co. established, recently, a world's record for the continuous operation of a multiple-element steam turbine of the cross-compound type. During this run, 51,104,000 kw.-hr. were generated, or considerably more than the total output of the Narragansett Co. for any year prior to 1915. In fact, this unit generated about 85 per cent of the total station output. Furthermore, this record was made with the load varying from a minimum of 6000 kw. to a maximum of 41,000 kw.

To some extent, this continuous operation was made possible by means of an 800-gal. self-contained lubricating system. Oil is pumped through a cooler to the bearings at the rate of 600 gal. an hour.

One of the most important features of this run was the fact that the turbine was operating under ordinary conditions. No preparation was made for the run, for, when the unit was started early last December, there was no thought other than to operate for a week, which is the ordinary period of a run. Abnormal weather conditions, however, brought about such a demand for power that it was not considered economically advisable to shut down the unit until the conditions were relieved. Even at this time it was not necessary to stop the turbine, but existing station conditions allowed this procedure.

"It is poor teamwork which calls for a hot head and cold feet."

Air Separation Process

ELIMINATION OF ECONOMIZER AND BOILER CORROSION BY AUTOMATIC MECHANICAL METHOD

IN THE OPERATION OF power plant boilers the problem of corrosion has been attacked from many sides with varying degrees of success; where natural water containing free acids has been used these have been chemically neutralized; even distilled water, such as condensate from surface condensers, has been found very active in causing corrosion and this pure water has been hardened to prevent the destruction of boiler metal; extreme care is taken to prevent electrolytic action due to the use of different metals in the boiler; then again electrolytic action has been encouraged under control by suspending zinc or other metals in the boiler, which, it is thought, will control the direction of the flow of the current, causing the zinc or other supplied metal to be eaten away but leaving the boiler steel.

The most recently advanced method of preventing boiler corrosion is to separate the dissolved gases from the boiler feed water, the theory being that the corrosion is caused, not by the water alone, but by the combination of water and dissolved gases. The idea upon which is based the method of separating dissolved gases from water, described in a paper presented at the spring meeting of the American Society of Mechanical Engineers by J. R. McDermet, research engineer for the Elliott Co., was originated by Wm. S. Elliott, of Pittsburgh, Pa. In his opinion, internal corrosion is a direct oxidation of the steel economizer surface accelerated in a small degree by the slight acidity of carbonic acid; but it is doubtful if the carbonic acid would exert any evil result without the oxygen. In other words, the

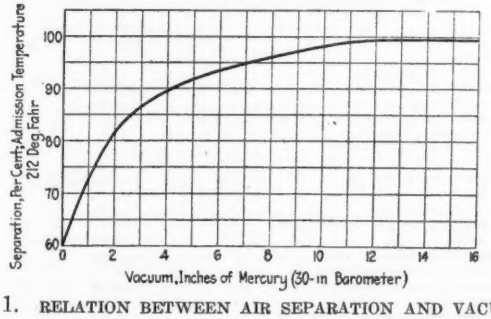


FIG. 1. RELATION BETWEEN AIR SEPARATION AND VACUUM

corrosion is simply a very pronounced case of rusting, similar to that which goes on in the atmosphere. The same applies also to boiler surfaces, but to a lesser degree. The sweep of the disengaging steam from the boiler surfaces tends to remove the dissolved oxygen from contact before direct oxidation can take place, and the coating of scale in a boiler mechanically protects the surfaces from contact with the oxygen. In spite of this, some cases of pitting result and, on account of the tendency of oxygen bubbles to cling to the roughened surface, the condition aggravates itself. Not all corrosion is due to direct oxidation, so that the claim is not made for air separation that it is a general cure for all boiler corrosion. Corrosion, however, on parts of the boiler where circulation is sluggish, can usually be ascribed, Mr. McDermet claims, to the direct action of oxygen.

Steam spaces in a boiler, together with the piping, are usually covered with a powdery coat of iron hydroxide, black or red in color, depending upon the water of hydration. This coating, which, in itself, is protective of the surface, is evidence of direct oxidation.

It was pointed out that, with waters containing dissolved magnesium chloride, the corrosive action is very much accelerated. Magnesium chloride is very soluble in water, and in boiler waters occurs in quantities which are limited by soil conditions of the water-shed from which the water is collected, and the solution is never saturated. The condition of magnesium chloride is, therefore, largely a matter of locality and is most serious in the southwest.

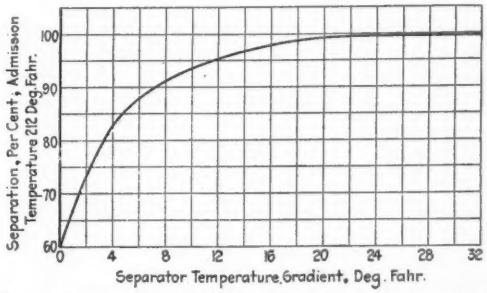


FIG. 2. RELATION BETWEEN AIR SEPARATION AND SEPARATOR TEMPERATURE GRADIENT

Experience has proved that magnesium chloride, as far as its effects are concerned, is regenerative, and, once introduced into a boiler, is never exhausted, but tends to concentrate by evaporation of the water, and can only be removed by blowing down. This regenerative action ceases in the absence of dissolved oxygen, so that dissolved oxygen may be regarded as a regenerative agent in the corrosion, due to magnesium chloride, or magnesium chloride as a catalyte in the corrosion of dissolved oxygen, according as one elects. The chemical equations of the reaction, as ordinarily given, are as follows:

$$Mg\,Cl_2 + H_2O = Mg\,O + 2\,H\,Cl \quad (1)$$

$$Fe + 2\,H\,Cl = Fe\,Cl_2 + H_2 \quad (2)$$

$$Fe\,Cl_2 + Mg\,O = Fe\,O + Mg\,Cl_2 \quad (3)$$

Not only will the separation of the gases from the water prevent corrosion, but, according to Mr. McDermet, it will cause the precipitation of certain scale-forming impurities. By Mr. Elliott's process of gas separation, described later, carbon dioxide is removed with other gases. Carbon dioxide dissolves in water to form carbonic acid, which is the solvent for all the scale-forming carbonate compounds in water; all carbonates are dissolved as bicarbonates, which simply means that the carbonates combine with carbonic acid. This statement applies to all the carbonates: calcium, magnesium, sodium, barium, etc. Upon this fact the following generalized statements are made. Carbon dioxide dissolves in water to form carbonic acid and, as such, has most of the properties of a true solution; some of it also is combined in a metastable compound with the dissolved

carbonates, forming bicarbonates, a combination in which it is spoken of as "half bound" carbon dioxide; and finally combined in a perfectly stable grouping of the carbonate radicle (CO_3) of the carbonates. In passing through the degasifying process, that part of the carbon dioxide which is truly dissolved, and that which is known as "half bound" is removed. With the removal of the "half bound" carbon dioxide the dissolved bicarbonates are reduced to carbonates, viz.:

$$H_2\,Ca\,(CO_3)_2 = H_2O + CO_2 + CaCO_3$$

While all of the carbonates dissolved as metastable bicarbonates are soluble to the extent that waters are enabled to saturate themselves in nature, the same is not true of the carbonates with the exception of sodium, which is soluble in all proportions. Magnesium carbonate is soluble only to the extent of 106 parts per million; calcium carbonate to the extent of 20 parts per million, and ferrous carbonate not at all. The immediate result of the removal of carbon dioxide is the precipitation of

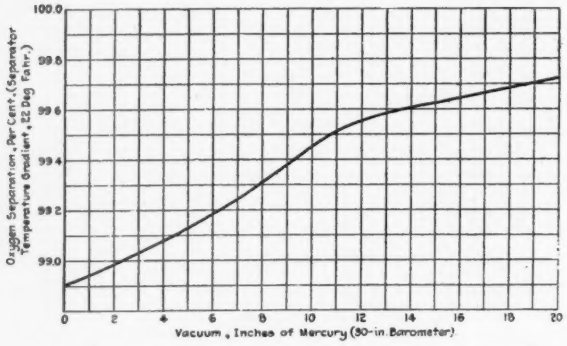


FIG. 3. RELATION BETWEEN OXYGEN SEPARATION AND VACUUM

carbonates in excess of the values given. Since calcium carbonate constitutes the bulk of scale-forming materials in normal waters, the method of air separation is also a method for the precipitation of scale-forming impurities. It is probable that this feature will result in the elaboration of the method to make of it a complete scale precipitation outfit at some later date.

Mr. McDermet classifies the impurities of natural waters commonly used for boiler feed purposes under three heads: dissolved gases, dissolved solids and suspended matter. Means have long been in use for successfully removing suspended matter and dissolved solids, but, until recently, almost no attempt has been made to remove the dissolved gases. This problem has been solved at the plant of the Elliott Co., at Jeanette, Pa., where, for some time, a 1000-hp. boiler installation has been in operation, the process employed separating completely, so far as methods of testing suffice to indicate, all nitrogen, hydrogen, oxygen and free or half bound carbon dioxide. The mechanism of this is chemical, but the process is altogether mechanical. The amount of gases dissolved by water, eliminating carbon dioxide from the discussion, is a perfectly definite quantity, dependent upon the temperature of the water.

Condensation of Air-Free Steam

The surface condensation of steam involves three distinct physical steps: the conduction of heat through a definite thickness of metal—the tube wall, and two boundary conditions, the transfer of heat from a vapor to a metal, and the transfer of heat from a metal to a liquid. In the surface condenser this latter condition is dependent upon the velocity, viscosity and temperature of the cooling water and the laws of the heat transfer are not definitely understandable. The other boundary condition is complicated in practice because the area exposed to steam flow is surrounded by a rarefied air film, so that, in reality, two heat transfers are involved: from the steam to the air film and from the air film to the metal surface. The elimination of this film of noncondensible gas and the attainment of an ideal boundary condition is all that the air separation can possibly attain. It is to be expected that it will increase the conductivity by eliminating the resistance of the air film and increase the vacuum by reducing the partial vapor pressure, but the intricacy of the experimental data is very apt to obscure the simple physical fact involved.

In the experiments conducted on surface condensation the boilers were fed with water which had been put through the air-separation process and which was practically air-free; and high-pressure steam was conducted to a cast-iron baffled cone bolted to the steam inlet of the condenser, expanded to condenser pressure, and allowed to enter the condenser with considerable velocity but no impingement. Two surface condensers of very dissimilar types were tested under these conditions.

In order to provide for as precise a comparison as possible between tests with air and those without air, a series of tests was run in which air was not extracted from the water before it entered the boiler, although

SPECIMEN LOG OF TESTS (CONDENSED)

	Separated	With Air
Date	8/23/17	8/23/17
Duration, hours	1	1
Barometric pressure, inches Hg	28.96	28.98
Condensate, lb.	2,988	3,201
Condensate, lb. per sq. ft. per hr.	9.91	10.61
Condensate temperature, deg. fahr.	89.1	87.1
Temperature cooling in, deg. fahr.	67.8	64.2
Temperature cooling out, deg. fahr.	82.8	80.4
Heat rise, cooling, B.t.u.	14.96	16.16
Weir head, ft.	0.682	0.682
Weir volume, cu. ft. per min.	5.852	5.852
Specific weight, lb. per cu. ft.	62.20	62.23
Weight cooling, lb. per min.	363.8	364.0
Weight cooling, lb. per hr.	218,322	218,424
Total heat to cooling, B.t.u.	3,266,097	3,538,469
Mean temperature differences log, deg. fahr.	76.7	73.6
Vacuum in condenser, inches Hg	28.60	28.57
Temperature of vacuum, deg. fahr.	89.5	90.2
Absolute pressure in condenser, lb. per sq. in.	1.40	1.43
Heat transfer, B.t.u. per sq. ft. per hr. per deg. fahr.	846	706
Vapor pressure of condensate, inches Hg	28.62	28.70
Cooling-water velocity, ft. per sec.	8.47	8.47
Cooling-water ratio	73	68

it was heated up to atmospheric temperature in the open heater of the separation equipment. Air was not admitted directly into the condenser because no means of measuring the quantity admitted was known which would be of consistent accuracy with the remainder of the experiments. Such tests as either of these series are evidently not representative of operating conditions, in that they were performed upon a condenser of air-tightness far in execess of anything attained in commercial operation. They are an attempt toward an ideal condition of condensation, however, and are offered as being of specific interest because they apply to an actual condenser.

On account of the volume of the data of these tests, some 3400 tubular values, it is not practicable to publish the complete log; however, a specimen log of two tests, condensed to about one-third of its original volume,

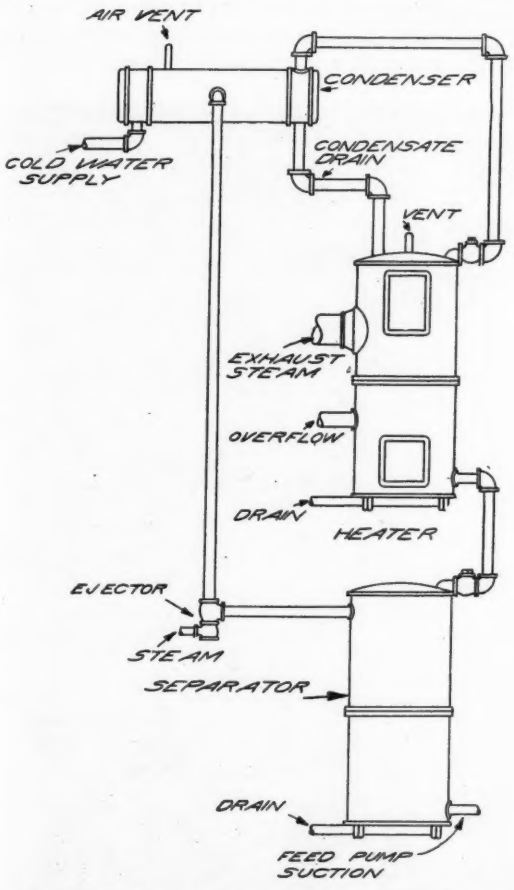


FIG. 4. DIAGRAM SHOWING SIMPLE ARRANGEMENT OF EQUIPMENT USED FOR AIR SEPARATION

is given in the table for the use of those who wish to make a numerical comparison between the two groups.

Process Outlined

Fundamentally, the process employed consists of heating the water to its approximate boiling point and

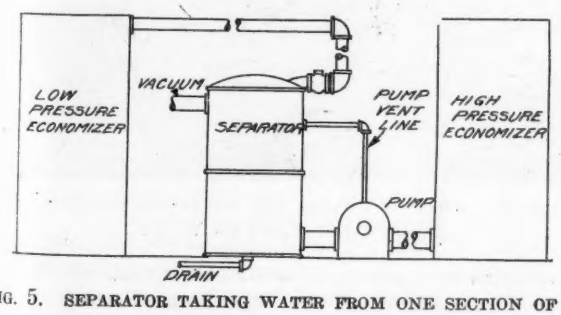


FIG. 5. SEPARATOR TAKING WATER FROM ONE SECTION OF AN ECONOMIZER AND DELIVERING TO ANOTHER SECTION

then injecting it into a chamber under vacuum. The vacuum is maintained by an air pump with a condenser or heat exchanger, in series, so that all the heat from the vapors exhausted from the region of vacuum is returned to the feed water heater through the heat exchanger and the process operates at 100 per cent efficiency thermally.

By referring to the diagram shown in Fig. 4, the sequence of the process may be followed. Water enters from the supply mains and passes through one side of the circulating system of the heat exchanger, from

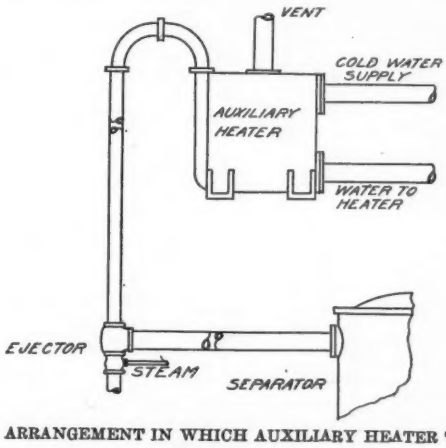


FIG. 6. ARRANGEMENT IN WHICH AUXILIARY HEATER TAKES PLACE OF ATMOSPHERIC CONDENSER

the heat exchanger it passes, still under supply pressure, to the inlet valve of the heater and is admitted to the heater under the control of the water level float valve. Having been heated to the operating temperature of the heater, it passes under gravity head to the float controlled valve of the separator. In proper time it passes into the separator, gives up its dissolved air and the major part of it passes on through the separator to the boiler feed pumps. A small portion of it, however, is evaporated under the vacuum conditions of the separator and is withdrawn mixed with the air from the water by the air ejector producing the vacuum.

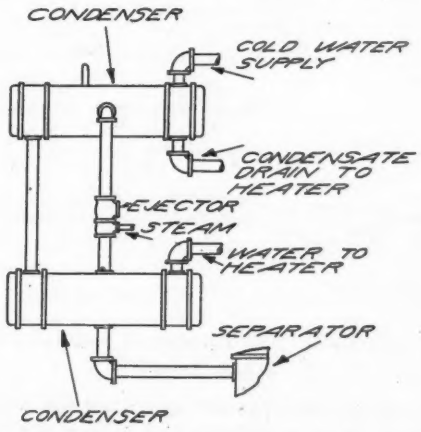


FIG. 7. ARRANGEMENT WITH CONDENSER INTERVENING BETWEEN SEPARATOR AND EJECTOR

The mixture of the air, vapor and ejector steam passes to the other side of the circulating system of the heat exchanger; the heat of the mixture is absorbed by the flow of the incoming supply water; the air escapes through the vent; and the condensate returns by gravity

to the heater. The process has, therefore, lost no heat and no water, and only the air has escaped. The only loss is the energy consumed in pumping out the air and in overcoming the additional suction head on the boiler feed pumps. The only cost is that of investment and, with a steam ejector air pump, there is nothing that moves except the water level float valves in the heater and separator; the apparatus is perfectly automatic in operation.

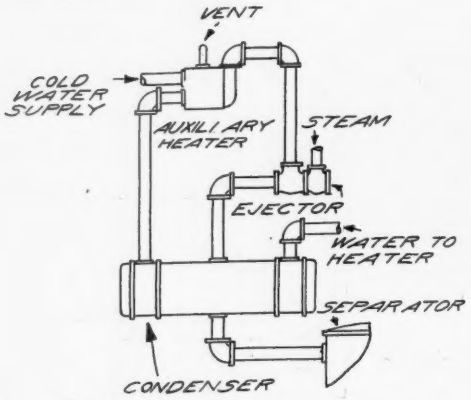


FIG. 8. AUXILIARY HEATER USED TO CONDENSE EJECTOR STEAM

The process admits of variations in arrangement of apparatus to suit particular operating conditions or to take advantage of opportunity to lower the investment charge. The separator may draw hot water from a heater and deliver the processed water to boiler feed pumps for direct feeding to boilers, which is the simplest application, since the process imposes its own conditions; the separator may draw its hot water from a heater and deliver it through feed pumps to an economizer, in this case all operating conditions are imposed upon the

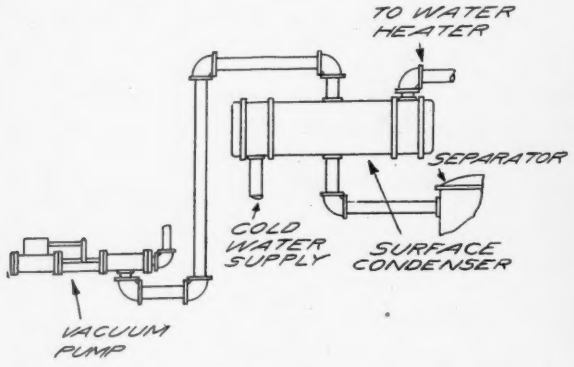


FIG. 9. AIR SEPARATING EQUIPMENT FOR LOW-PRESSURE STEAM PLANTS

process; again, the separator may draw hot water from one section of an economizer and deliver it to another, this is the most difficult application, since the operating conditions are both imposed upon the apparatus and are uncontrollable within fairly wide limits.

Irrespective of the conditions under which the process operates, several arrangements of auxiliary equipment are desirable to take advantage of the users' operating conditions for his own benefit, either by a reduction in investment charge or decrease in the steam consumption of the ejector. It is the expectation that an ejector will be used wherever steam for its operation is available, since this is an ideal application for an ejector and no other type of air pump can compete with it economically.

In the arrangement shown in Fig. 6, an auxiliary heater is combined with an ejector, the auxiliary heater

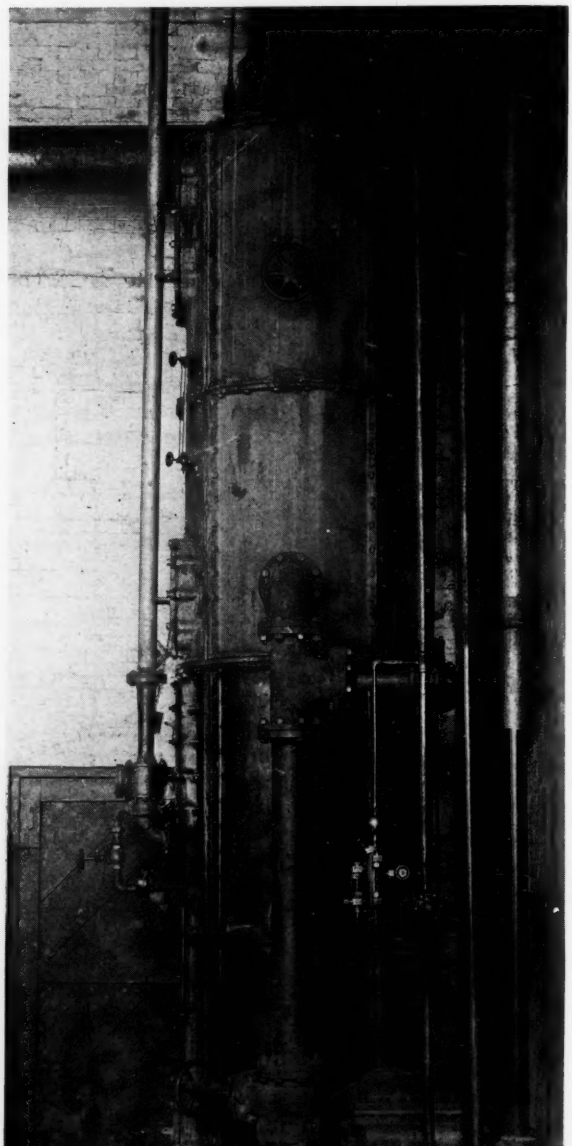


FIG. 10. VIEW OF HEATER AND AIR SEPARATOR INSTALLED IN THE ELLIOTT CO. PLANT

being on the atmospheric side. This is applicable in any conditions where sufficient gravity head can be given to permit the feed water to flow into the main heater, but is not desirable on widely fluctuating loads, since the auxiliary heater has no water storage capacity to condense the ejected steam. Any arrangement with the

ejector between the condensing apparatus and the separator, as shown in Figs. 4 and 6, has twice the steam consumption of the types with a condenser intervening, Fig. 7. In one case, the ejector handles the vapor mixture, in the other, only the air. Water control is obtained from the float of the main heater, and the auxiliary heater has very little water storage capacity in itself.

A surface condenser may be combined with the ejector, in place of the auxiliary heater. This permits of carrying water supply pressure up to the control valve on the heater. The condensate from the condenser may be trapped to the heater if sufficient elevation is possible in the location of the condenser; otherwise may be returned to the hot well, since its temperature will be virtually that of the incoming water.

By another arrangement the condensing capacity is split into two parts with the ejector between, Fig. 7, one part handling the vapor mixture from the separator and the other operating the steam from the ejector. The condensate from the vacuum condenser is allowed to drain back through the vapor pipe since it will suffer no contamination from the rarefied air in the vapor mixture; the condensate from the atmospheric condenser is handled as has been explained above.

The auxiliary arrangement, shown in Fig. 8, has the advantage of lower cost, as compared with that shown in Fig. 7, but should be used only in installations of relatively high capacity.

For ice plants and central station heating, where high-pressure steam may not be available for operating an ejector, the mechanical air pump arrangement, shown in Fig. 9, has been devised.

The physical features of the process are the same, irrespective of the arrangement of the apparatus. The heated water is introduced into the separator, which is maintained under vacuum pressure, the vapor pressure of which, by virtue of the vacuum, is appreciably lower than the vapor pressure of the heated water. Entering the separator at this low pressure, the water boils violently at the expense of the heat of the liquid until it comes into equilibrium temperature condition with the vacuum. In the process of explosive boiling, the steam bubbles form about the air bubbles as nuclei and remove the air when they pass into space.

In the operation of the process, a drop in temperature of 22 deg. F. is arbitrarily given the water in the separator. This amount is given, as it provides a value upon which to figure with perfect safety, provided the initial temperature of the water entering the separator does not fall below 175 deg. F. Below this value, it is impossible to give a special rule for guidance, although the process is workable. This, incidentally, gives an approximate temperature of 150 deg. F. for the water leaving the separator, and an economizer tube sweats at a temperature below 120 deg. F., so that there will likely be very few cases to which this rule does not apply.

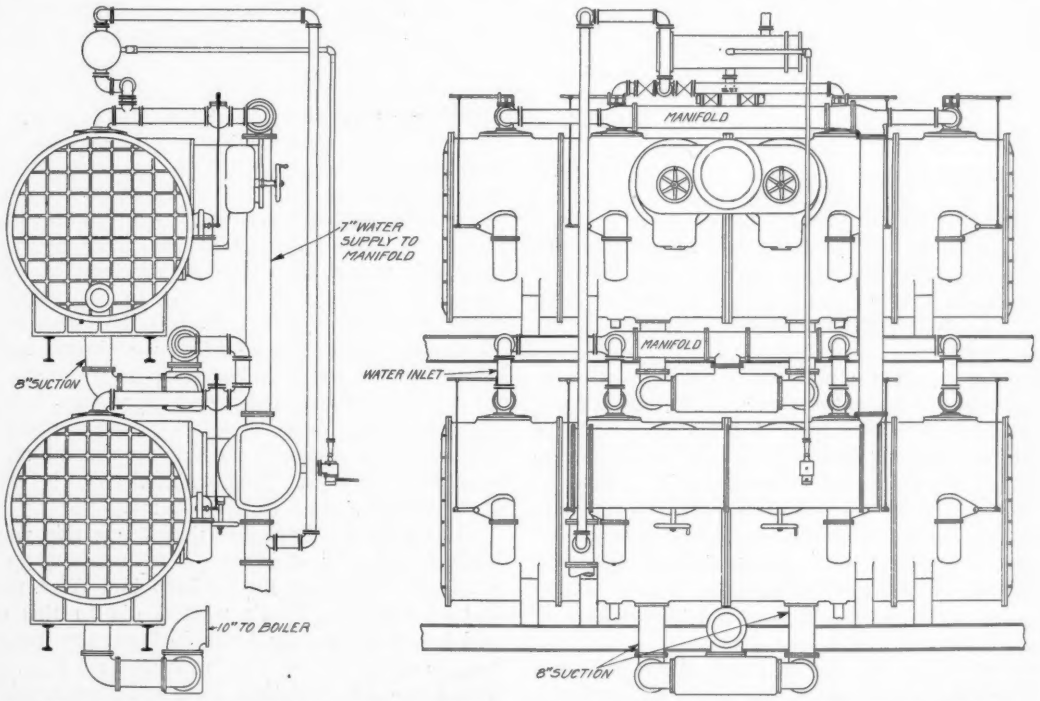


FIG. 11. END AND SIDE ELEVATIONS OF AIR EXTRACTOR EQUIPMENT EMPLOYING DUPLICATE HORIZONTAL HEATER AND SEPARATOR

The vacuum will always be equal to the atmospheric pressure minus the vapor pressure of the liquid at the temperature of the water leaving the separator. The amount of condensate is found by dividing the total heat of the vapor at the initial temperature by the drop in heat content in the separator and multiplying by the total weight of the water. The heat abstracted by the separator and recovered by the condenser is equal to the drop of heat content in passing through the separator, multiplied by the total number of pounds.

The increase in pumpage head on the boiler feed

pump is equal to the vacuum translated from inches of mercury into feet of water; i. e., multiply by 13.6 and divide by 12.

The actual amount of air removed depends upon the temperature at which the water entered the pipes from the natural source of supply. This original content is, however, immaterial, for experiments have proven that the extent of the separation does not depend on the original content, but approaches an irreducible minimum which is indeterminate, for the reason that it lies below the probable error in both physical and chemical means of testing. When the separator is used in connection with an open feed water heater, the extent of the separation must be considered as in excess of 60 per cent, as water heated to boiling loses about 60 per cent of its dissolved air because of decreased solubility by temperature. Usually, this air merely collects in bubbles entrained in the liquid and does not escape, so that the separator must remove all of it.

The results to be obtained by air separation by the process described above may be summarized as follows:

(A) Power Plant Boilers.
  (1) Elimination of direct oxidation of economizer surfaces.
  (2) Elimination of direct oxidation of boiler surfaces.
  (3) Elimination of regenerative hydrolytic action of magnesium chloride and hydrochloric acid.
  (4) Elimination of direct corrosive action and electrolytic corrosive action of carbon dioxide.
  (5) Precipitation of dissolved calcium carbonate in excess of 20 parts per million.

(B) Central Station and Building Heating Plants.
  (1 to 5) Same as above.
  (6) Elimination of direct oxidation of all service pipe lines and condensing surfaces.

(C) Surface Condensation.
  (1) Increased conductivities.
  (2) Higher vacuums in condensers operating a vacuum higher than 29 in. mercury.

Future Engineers

By H. A. Cranford

A CONVERSATION that I recently had with a young fellow impressed me very much. He was just back from the army, and as I had been his friend, and, in a sense, his adviser, before the war, when he was discharged he came to me to talk over his future prospects.

There is no question in my mind but that his mechanical talents are far above the average. He would make a good engineer or electrician. I know he would, for he has worked for me and I have had the chance to study him. When I asked him if he had decided on a line of work, he replied that he thought that he would take a place that was offered him in a local wholesale drug house, and take a night course with the K. of C. organization. He said there was "no money in the trades," and he had decided on being "some kind of professional man."

I reminded him of the fact that there is now a great shortage in the trades, especially the ones for which he had talent, and in the work that I knew he loved. He knew that I had been trying for weeks to find a man competent to take my place here for a month, that I might get away to attend to some pressing affairs. I explained that there were not a half dozen bona-fide engineer apprentices in this city, and that as fast as the old guard died, there was a greater shortage in the trade because there were no young men coming on to take their places. I explained that never in the history of this country were there as many new industries springing up, making places for more engineers and electricians. Because I see the greatest future for good engineers and electricians, I tried to make him see through my eyes. After I had offered him all the reasons I could think of for taking up the work that he was "cut out for," he gave me his view of the matter.

First, he asked me what my salary was at the present, after 22 yr. in the work. He then named a number of accountants, dentists, lawyers, doctors, etc., that were making as much, and some of them more, and said that their job was a *clean clothes* job, besides. He also asked me how long I had to be an apprentice before I was given my papers. In fact, he asked me about all the questions that all of you engineers have been asked from time to time by young men who are looking for something easy, a way to get by, without much effort on their part. Very few of them can see any reason for doing the apprentice drudgery around an engine room for 3 or 4 yr. They are anxious to be engineers, if they can be chief in 6 to 12 mo.

I said in the beginning that I was this young fellow's friend, and it is sometimes necessary to handle a friend pretty roughly to keep him from making a fool of himself. That's what I did in this case. I told him that possibly *he* could learn the trade in far less time than it took me, for it took me 3 yr. to learn that I was an egotistical fool, and then another year to *begin* to learn the trade, and that after I got started to learn the trade and got all the conceit out of me, I had been learning every day since, except during the time I spent regretting that I ever thought I knew it all during the first 3 yr.

I then proposed to him that we carry on a little investigation of things before he made his final decision. I proposed that he take the job in the wholesale house for a few weeks, while we looked into the matter. Our investigation brought out the following facts:

The business colleges were full of students of all ages, from 14 to 50 yr. of age. They were being graduated from them like chickens hatching out in an incubator. We obtained the names of a number of those who had completed the courses in the years before and found that out of about 100, only 42 were still in that especial line in which they had taken courses, that the average salary of those that we could get a line on was far below the average of engineer's helpers, and that

their hours were on an average longer. A number of the young men that we talked to regretted that they had not gone into the trades in the beginning.

In one day's "want columns" we found 55 "ads" for positions wanted as stenographers or bookkeepers. We did not find a single mechanic advertising for work. We found that practically all the first-class engineers and electricians that we were acquainted with owned their own homes. Only five of the bookkeepers and stenographers that we were acquainted with owned their homes. Being acquainted with the managers of several office buildings, we began to look up some facts concerning doctors, lawyers, etc. Of the number that we could get a line on, a surprisingly small number were meeting their bills promptly. They had not only been in school as many years as an apprentice has to serve, but had been made to *pay* for their learning instead of *getting paid* for learning, and then had to sit and wait until clients came to them.

Through the help of a lawyer friend, we got a list of the bankrupts for 2 yr. There was every profession represented, either through voluntary or involuntary proceedings, *but not an engineer or electrician* in the list.

We found out other things too numerous to mention here. The result is that my friend will start in to finish an apprenticeship in the industrial trades. Too many good engineers are spoiled by trying to make them into preachers, doctors, etc. If there isn't something done to bring young blood to its senses, it is only a matter of time until the industries are going to suffer. Youth and inexperience must be educated to the fact that a pair of dirty overalls may be a recommendation, and that this fast growing idea of all the money, honor and glory being in the professions, is all wrong.

Now, there is a certain amount of the blame for things being as they are to be placed on the engineers. Recently a young man who had worked at the trade for about 6 yr. came to me and stated that he wanted to try for his license and asked me to assist him. I asked him why he did not ask his chief to help him, and he replied that his chief had never shown him a thing yet, and it vexed him for one of the boys to ask him. I knew positively that this young man was a good, safe, practical engineer, and should have had his license before this. The only thing that he was liable to fall down on was his decimal problems. I helped the boy study decimals, and in a short time he passed a very creditable examination. I asked his chief one day what his idea was about helping his men to better positions. His reply was that if you taught them everything about the plant, the first thing you knew they would be rolling you for your job.

Now, if I cannot hold my own against any man, it's time I was making a change, anyway; and I wouldn't have a job that I thought my apprentice could hold. By the time he is ready to take my place, I should be advanced far enough to be ready for a better place, and I want to say right here that I never lost anything yet by helping any man to be a *better* man in any walk of life. It has paid me the biggest dividends and been of more satisfaction to me than any part of my work, and I intend to help young men just as long as my help is needed. I want every one of the men under me to be able to do something that is to be done, and do it intelligently. I think that it is not only a big aid to the chief, but reflects great credit on him, and, until we do our part toward the beginners, for pity's sake, quit "cussing" about the class of help we have to put up with.

The man who is afraid to help the other fellow is simply afraid of himself because he knows his own deficiency, and is not confident of his own ability to meet the world in open competition. When I find that I am on a job that anybody can come along and hold, I am going to change jobs. I don't want that kind. I can't see where I will ever get anywhere holding on to that kind. There are so few young men learning the trades that the scarcity is going to be in the good positions for longer than I shall live, and I shall assist the boys to get ready for my place when I am ready to go to a better.

We have no right to growl so much about jack-leg engineers, because we have the making of real engineers in our hands. And for the sake of the future welfare and prosperity of this country and its industries, let's take a deeper interest in the younger fellows and make real engineers out of the material as it comes under our hands. Most of us would have been pretty far down the scale if we had not had some assistance in the young days, regardless of the fact that we all like to say that we had to "dig" for ours. And I am glad of the fact that the man who was a real help to me in those bygone years is still living and is one of the best engineers in the South; that I can say to L. W. Cursey, Memphis, Tenn., that the fundamental principles that I learned under him were right, and have held good for these 20 yr., and that the widow's son whom he taught believes implicitly in the principles then learned.

Injured Bearing Used Five Days

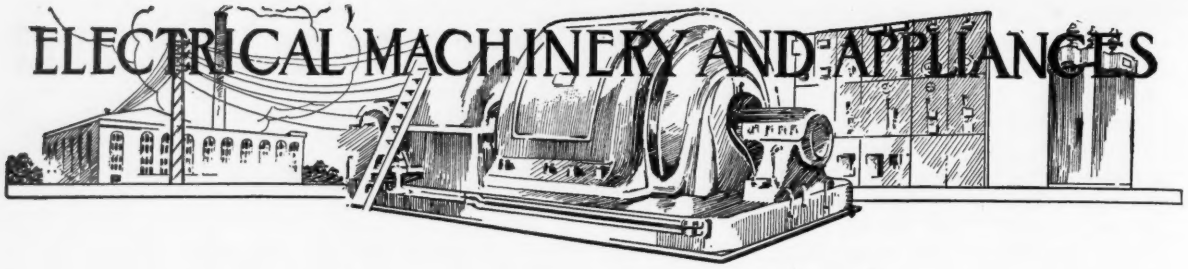
THE MAIN bearing on the right-hand side of a 300-hp. Ball variable speed engine became heated to the extent of burning most of the babbit from the shells.

This engine runs from 50 to 235 r.p.m. At the time the bearing was heated, it was running 228 r.p.m. The engineer noticed the shaft started to pound and saw the smoke coming from the bearing. Discovering that the oil had stopped flowing, he proceeded to try to cool the bearing without stopping the engine by lubricating it with cylinder oil, which he succeeded in doing. At this time, there was no sign of the babbit being run or burnt out. This happened on a Tuesday afternoon and the engine was run at 230 r.p.m. until Sunday morning. When the bearing was taken down, it was found that there was a strip of babbit 1 in. wide and 4 in. long on the two outer edges of the shell on the crank end and a spot on the head end shell 3 in. square. There was a portion of burnt and ground babbit in the bottom of the bearing.

The peculiarity of this bearing is that it did not heat running at high speed and under the conditions to which it was subject, as the babbit, being burnt out, caused a hard knock and the temperature of the engine room ranging from 90 to 110 deg. F., the shaft was in as good condition as if it had not been heated.

C. J. MILLER.

ELECTRICAL MACHINERY AND APPLIANCES



A Study of Dynamo Electric Machinery---XV

THEORY OF OPERATION AND CHARACTERISTICS OF THE DIRECT-CURRENT MOTOR. BY OTTOMAR H. HENSCHEL

ELECTRIC motors are employed for the conversion of electrical energy into mechanical energy and, as in the case of the generator, electromagnetic induction is utilized, although, as the function of the machine is reversed, so is the process of conversion reversed. Briefly stated, the functioning of an electric motor is due to the reaction of (1) the magnetic field surrounding a set of conductors carrying an electric current and mounted on an armature and (2) the magnetic field in which the armature carrying these conductors is placed.

A and B, Fig. 105, are shown sections of electric conductors, the former as indicated by the carrying current in a direction down through the plane of the paper with that at B carrying current in a direction up through the plane of the paper. Direction of the magnetic lines of force created by the current flow and surrounding these conductors is then as shown, those in the case of the conductor, current flow through which

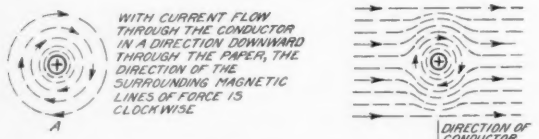

WITH CURRENT FLOW THROUGH THE CONDUCTOR IN A DIRECTION DOWNWARD THROUGH THE PAPER, THE DIRECTION OF THE SURROUNDING MAGNETIC LINES OF FORCE IS CLOCKWISE
A
IF, HOWEVER, THE FLOW OF CURRENT IS REVERSED, SO WILL BE THE DIRECTION OF THE SURROUNDING MAGNETIC LINES OF FORCE
B
FIG. 105
DIRECTION OF CONDUCTOR MOVEMENT
THE EFFECT OF THE RESULTANT FIELD IS SUCH AS TO CAUSE THE CONDUCTOR TO MOVE IN THE DIRECTION INDICATED
FIG. 106

FIG. 105. RELATION BETWEEN CURRENT FLOW THROUGH A CONDUCTOR AND DIRECTION OF RESULTING MAGNETIC LINES OF FORCE

FIG. 106. EFFECT OF CURRENT-CARRYING CONDUCTORS WITHIN A MAGNETIC FIELD

is in a direction down through the plane of the paper, being in a clockwise direction and those where the flow of current is opposite being counterclockwise.

As shown in Fig. 105, the magnetic lines of force encircling a conductor carrying an electric current are concentric, the intensity decreasing as the distance from the conductor increases. If, however, a conductor carrying an electric current is placed within a magnetic field, as indicated in an elementary manner in Fig. 106, it is apparent that, on the side of the conductor where the direction of the magnetic lines of force of the magnet is the same as those, due to the current flowing through this conductor, the intensity of the magnetic field is increased while on the the other side because of the opposing lines of force, the field is weakened. As a result, the conductor is forced in the direction indicated, that is, from the portion of the field of greater intensity to that of lesser intensity. This is the principle underlying the operation of the electric motor.

Figure 107 illustrates a simple two-pole motor equipped with but a single field coil and a single-coil armature fitted with a two-part commutator; a longi-

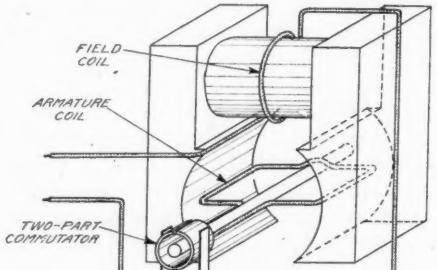


FIG. 107. THE ELEMENTARY DIRECT-CURRENT MOTOR

tudinal section through this machine is shown in Fig. 108. With the armature coil in the position indicated, direction of current flow is from the left-hand segment along the left half of the coil (that is, in Fig. 108, downward through the plane of the paper) through the back connection and thence along the right half to the connecting segment. Under these conditions and assuming the left pole face to be "north," the magnetic field above the left inductor is of greater intensity than that below and similarly in the case of the right inductor the intensity of the magnetic field below is greater than above. That, as a consequence, the coil will tend to revolve in the direction indicated by the arrow, is obvious. When, however, the coil moves sufficiently far to bring its plane perpendicular to the magnetic lines of force of the field, the current flow through the coil is reversed, this by means of the commutator provided for the purpose. It is thus evident that rotation will continue in the same direction, for, while the direction of current flow has been reversed, the relative directions of field magnetic flux and conductor magnetic flux remain unchanged.

Induced Electromotive Force

As in the generator, the armature conductors of a motor cut the magnetic lines of force comprising the field flux and, therefore, have induced within them an electromotive force dependent in value upon the total number of magnetic lines of force cut, the number of conductors in series and the number of revolutions made per minute by the conductors.

In the study of the generator it was explained how, when an electric conductor moves across a magnetic field at such a rate as to cut 100,000,000 lines of force per second, it will have induced within it an electromotive force of 1 v. Similarly, if two conductors connected in series are caused to cut 200,000,000 magnetic lines of force per second, or if four conductors connected in series cut 100,000,000 magnetic lines of force per second, the induced electromotive force will in each case be equal to 4 v.

With E representing the average number of volts induced, F the total number of lines of force cut, Z the number of conductors in series and the N the number of revolutions made per minute by each conductor, the value of E may be determined by the following formula:

$$E = F Z N \div (100{,}000{,}000 \times 60)$$

Such an electromotive force, because of the fact that it opposes the applied electromotive force, is commonly termed "counter electromotive force." The value of the required applied electromotive force is equal to the sum of this and the drop in the armature winding, or

$$E' = E + Ia\,Ra$$

where E′ is the applied electromotive force, E is the counter electromotive force, Ia is the armature current and Ra the resistance of the armature winding.

Transposing the foregoing counter electromotive force formula, we have the following fundamental speed equation of the direct-current motor:

$$N = [E(100{,}000{,}000 \times 60)] \div F Z$$

Automatic Adjustment of Current Flow

From the formula $E' = E + Ia\,Ra$, we can, by transposition, readily determine the value of the current, Ia, or the value of the counter electromotive force E, this, of course, under the assumption that the value of each of the other factors is known. The armature current Ia is equal to $(E' - E) \div Ra$, and the counter electromotive force E is equal to $E' - Ia\,Ra$.

In a given machine, the resistance of the armature winding, Ra, is fixed so that with constant applied electromotive force the speed and consequently the counter electromotive force and the current flowing through the armature will remain constant as long as the load is constant. Should, however, the load be increased, the motor armature will tend to slow down and, as a result, the counter electromotive force E is reduced. But from the foregoing formula we know that $E' = E + Ia\,Ra$, and with E′ and Ra fixed, this condition can hold good only by an increase of Ia, the armature current. It is in this way that a motor is made to draw an increased amount of current with increased load.

With a reduction of load, the opposite occurs. The speed of the motor will tend to increase, thus raising the value of the counter electromotive force E and making $E + Ia\,Ra$ greater in value than E′. If, however, stable operation is to maintain, this cannot remain so and, as before, E′ and Ra are fixed, the armature current (due to the increased value of the counter electromotive force E) is reduced so as again to make $E' = E + Ia\,Ra$.

Let us assume, for example, that the electromotive force applied to the terminals of a motor is 110, that the resistance of the armature winding is 2 ohms and that it is desired to determine the increase of armature current due to a decrease of counter electromotive force from 100 to 90 v. as a result of a reduction of speed brought about by added load. The value of the armature current Ia is, as shown above, equal to $(E' - E) \div Ra$, or, in this particular case, $(110 - 100) \div 2$, which, we find, is 5 amp. Increase of load has, however, resulted in a drop of counter electromotive force to 90 v., so that now we have the value of Ia equal to $(110 - 90) \div 2$,

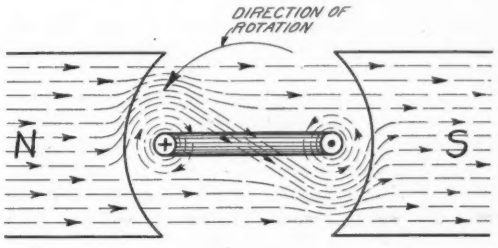


FIG. 108. LONGITUDINAL SECTION THROUGH MOTOR SHOWN IN FIG. 107

or 10 amp. Thus it is seen that, with a reduction in counter electromotive force of but 10 per cent, the armature current is increased 100 per cent.

Motor Torque

Torque in a motor, that is, its turning moment, is due to the action of the field upon the armature conductors and is therefore proportional to the product of F, the total flux, and Ia, the armature current. Torque, which is generally expressed in pounds-feet, may be determined by measuring the pounds pull of the motor belt and multiplying this by the radius of the pulley in feet. Thus, with a 2-ft. pulley and a belt pull of 150 lb., the torque would be 1×150, or 150 lb.-ft.; likewise in the case of a pulley having a radius of 1½ ft. and a belt pull of 100 lb., the torque would also be 150 lb.-ft.

Types of Motors

According to winding connections, there are three distinct types of direct-current motors, namely: series, shunt and compound. These are shown in diagrammatic form in Fig. 109, at A, B and C, respectively.

Except while being started and when under variable speed control, both armature and field windings of the shunt motor are connected directly across the supply mains which ordinarily should be maintained at a constant difference of potential. It is thus evident from the fundamental equation of the direct-current motor that with constant supply line voltage and as long as the load is constant, the speed of the machine will remain unchanged. With no load, the counter electromotive force is nearly equal to the applied electromotive

force, the voltage drop across the armature windings, that is, the R Ia drop, is appreciably small, as is also the armature current, Ia. As soon, however, as load is thrown onto the motor, it is necessary to bring about a sufficient drop in counter electromotive force to allow that current flow through the armature windings which will provide the required torque. As already shown, the drop in electromotive force is partially due to a slight drop in speed; but, because of the increased flow of current through the armature windings, armature reaction increases and, as a consequence, aids materially in the reduction of counter electromotive force. Thus it is obvious that but a slight drop in speed accompanies increase of load on a shunt motor and it is for this reason that this type of machine is ordinarily referred to as a constant-speed motor.

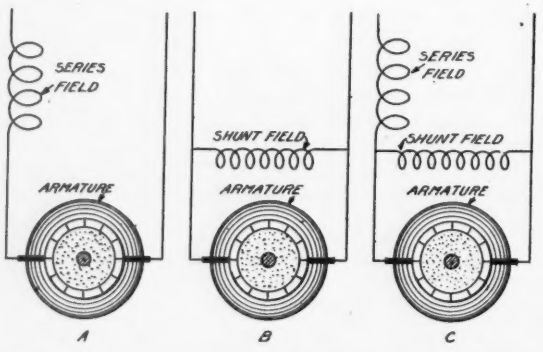


FIG. 109. ELEMENTARY DIAGRAMS OF CONNECTIONS OF SERIES, SHUNT AND COMPOUND WOUND MOTORS

Other factors affecting the speed of such a machine are the position of the brushes and the heating of the windings. With the brushes in a neutral plane, the counter electromotive force induced is a maximum and the speed at a minimum value. Shifting of the brushes, however, as in the case of the generator, renders a portion of the armature conductors inactive in the induction of counter electromotive force with the result that the flow of armature current is increased as is also the torque and consequently the speed.

Heating of the windings results in increased resistance, reduced field strength and a rise in speed. This action is, however, more than offset by the armature voltage drop with increase of load, which, as already stated, produces a slight drop in speed.

Shunt motors are but little susceptible to speed drop due to line voltage drop, the per cent of speed change being considerably less than that of voltage change. Actually the former is from 0.6 to 0.8 of the latter, so that with a 10 per cent drop in line voltage a drop of but from 6 to 8 per cent may be expected.

Speed Regulation

While, theoretically, the shunt-wound motor is a constant-speed machine, practically this is not so. Drop in speed is bound to occur with increase in load, and vice versa. Change in speed from full load to no load, expressed as a percentage of full-load speed, is called the speed regulation of the motor, voltage of supply and resistance of armature and field windings being maintained constant.

Speed Control of Shunt Motors

Speed control of shunt-wound motors may be accomplished by any one of five means:

(1) Armature current control.
(2) Field excitation control.
(3) Reluctance of magnetic circuit control.
(4) Multivoltage control.
(5) Variation of voltage.

By the first-mentioned method, a variable resistance is inserted in the armature circuit, but, due to resulting poor regulation, the large and expensive rheostat required and the inefficiency due to its use, this scheme is not extensively employed.

Although the range of speeds obtainable by varying the degree of field excitation is quite limited (generally not in excess of 30 per cent), the efficiency of a system employing this arrangement may be kept quite high. A variable resistance rheostat is connected in series with the field winding and, as more of this resistance is cut into circuit, less current flows through the field windings, the field flux is decreased, as is also the counter electromotive force. As a result, the armature current, the torque and consequently the speed increase.

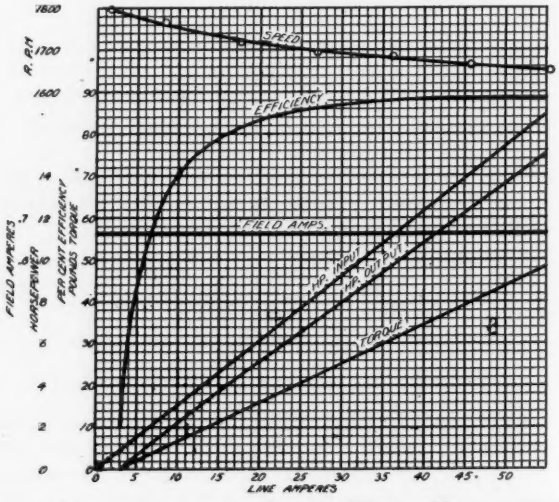


FIG. 110. CHARACTERISTICS OF A 230-V., 10-HP. SHUNT-WOUND MOTOR

In the third-mentioned method, the strength of the magnetic field is likewise varied; however, instead of varying the degree of excitation, the reluctance of the magnetic current is increased or decreased according to whether decreased or increased speed is desired. In one make of machine, this is accomplished by making the field poles hollow and placing within each a snugly fitting cylindrical iron core. By means of a system of bevel gears mounted on the frame and operated by a hand wheel, these cores may be moved inward or outward, thus providing a means for increasing or decreasing the width of the air gap.

In the multivoltage scheme, the field is connected directly across one set of supply lines while the armature through the medium of a suitable controller is connected successively between different pairs of mains. Actually this is a multispeed rather than a variable speed arrangement.

A more elaborate system is that employing variable voltage. In connection with this and receiving energy from the same source as the motor field coils is used a motor-generator set, the generator end of which supplies current to the motor armature. It is thus evident that, as the electromotive force of the generator is varied, so is the speed of the motor.

The Series Motor

As its name implies, the series motor is one in which the armature and field windings are connected in series in the manner indicated at A, Fig. 109; therefore, as is obvious, the same current passes successively through the armature and field windings. Torque, as already explained, is proportional to the product of the armature current and the strength of the field and as the field strength increases as does the armature current, the torque of a series motor increases as the square of the current flow. This, however, is true only up to the point of saturation of the field magnets; in proximity to and beyond this point, increase in current flow produces but a slight increase in field strength and as a result the torque will then vary only as the current. From the characteristics of a series-wound motor, as shown in Fig. 111, it will be seen how the torque curve varies inversely as the speed, thus rendering this type of motor particularly applicable where the factor of speed is of minor importance, but where a high starting torque is desirable. As a result, the series-wound motor finds its greatest utility in the fields of electric traction, fan, crane or other work not requiring constant speed, but at all times insuring a constant load, without which the motor would tend to run away, with consequent damage, not only to the motor, but also in many cases to the driven machine or machines.

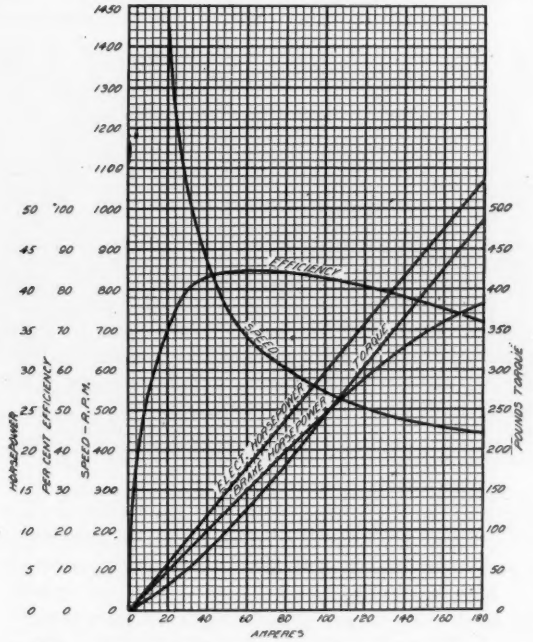


FIG. 111. CHARACTERISTICS OF A SERIES-WOUND MOTOR

The speed of such a motor is ordinarily varied by shunting the field, shunting the armature or, as in the case of electric railway work, by inserting an adjustable resistance in series with field and armature windings. With the latter method for a given load the motor draws the same current, regardless of speed, and the speed varies with the applied voltage.

After a series motor has been brought up to its normal speed by means of some form of starting rheostat, increase in speed at a given load may then be realized by inserting a resistance across or in shunt with the field, this action being due to the reduction in current flow through the field winding with accompanying decrease of field strength. On the other hand, assuming that all of the starting resistance has been cut out of circuit, connecting a resistance in parallel with the armature will result in a reduction of speed, an arrangement especially useful where low speed is desired at light loads.

Compound-Wound Motors

Essentially, a compound-wound motor is a combination of a series- and a shunt-wound motor with the result that, as may be expected, it partakes of the characteristics of both of its component elements. Elementary connections of a compound-wound motor are shown at C, Fig. 109, while Fig. 112 illustrates the characteristics of such a machine.

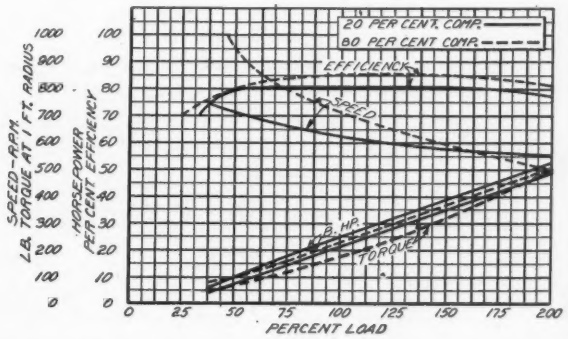


FIG. 112. CHARACTERISTICS OF A TYPICAL COMPOUND-WOUND MOTOR

Either one of two general schemes may be used to connect the field coils of a motor of this type. The series field may be made to assist the shunt field, in which case the machine is referred to as a cumulative compound-wound motor, or the series and the shunt fields may be made to oppose one another. Under such conditions, the term "differential" is generally employed.

Cumulative compound-wound motors have the advantage of a heavy starting torque and an approximately constant speed although not equaling that of the differentially-wound machine. As in the case of the shunt-wound motor, the speed of a differential compound-wound motor, due to the action of the shunt winding, tends to drop slightly with increase of load. However, as the load increases, the current flow through the series windings increases accordingly, as does also the strength of the field, due to the action of the series winding. But, because of the fact that shunt and series coils are wound in opposite directions, the effect of increase of series field is to tend to decrease the strength of the field acting upon the armature and, as a consequence,

due to this slight weakening of the field, the speed of the motor increases. The current through the series winding is greater the heavier the load, hence the magnetization is reduced and practically perfect speed regulation obtained.

In general, speed and torque characteristics of a compound-wound motor are determined by the relative influences of the series and shunt fields, so that by varying these factors in any ratio desired, speed and torque characteristics may be made to approach those of the series-wound motor with just sufficient shunt field effect to prevent running away of the motor at light loads. In a similar manner, they may be made to approach the constant speed characteristics of the shunt machine.

QUESTIONS AND PROBLEMS FOR REVIEW

How do you explain the theory of operation of the direct-current motor?

How is the flow of current automatically adjusted?

2. A motor is fitted with a 36-in. pulley and the pull on the belt, as measured by a spring scale, is 400 lb. What is the torque in pounds-feet?

3. Name five different means by which the speed of a shunt motor may be controlled.

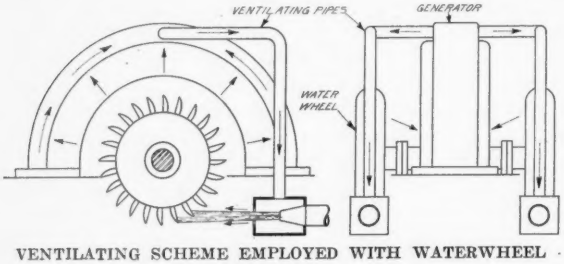
4. Explain the action of the compound-wound motor.

Increasing Generator Capacity

By C. C. Brown

FOLLOWING is the description of how a 3500-kw. water-wheel generator was altered so that it would carry 4000 kw. and run much cooler than when carrying its normal rated load.

This generator, which was an old alternator rated at 3500 kw., was directly connected to two Pelton overhung



VENTILATING SCHEME EMPLOYED WITH WATERWHEEL GENERATOR

water wheels and had been giving trouble by heating up abnormally at rated and less than rated load. As a consequence of this fault, the station was greatly handicapped, as it was practically impossible to count on this unit. Many things had been tried in vain endeavor to remedy the difficulty, but nothing seemed to turn the trick.

Finally one of the operators conceived the idea of increasing the natural ventilation of the machine as shown in the sketch. The idea was to make use of the suction which was produced around the nozzles of the Pelton wheels, for the purpose of pulling the heated air out through the ventilating ducts of the frame.

With this end in view, a sheet-iron box or channelway was built around the outside of the frame and so placed and sealed that no air could leak around or underneath it, while it acted as a manifold for an outlet for all of the air ducts in the frame.

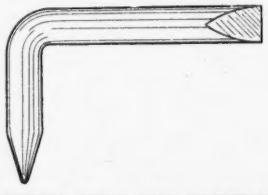
A sheet-iron pipe was then tapped into this channelway on either side, and led over and down to the boxes constructed around each of the Pelton wheel nozzles.

By the use of this method of ventilation, it was ascertained that the more the load, the greater the suction and hence the better the ventilation. Needless to say, we were troubled no further with heating on this machine and found that when carrying 4000 kw., the generator actually ran cooler than it did when carrying 3500 kw.

Screwdriver for Electrician's Use

By W. S. Standiford

A HANDY screwdriver that every electrician should have in his tool kit is made by bending a piece of 3/8-in. round rod of tool steel to a right angle and grinding the ends flat to fit the slot in a screw. It is best to have the working ends of the bar ground at a right angle to each other, as shown in the illustration. When working in a position where there is not much



SCREWDRIVER WITH TWO WORKING ENDS

space in which to use a screwdriver, this enables the user of the tool to get another hold on a screw by using the other end of the tool. Owing to the shape of this tool, the user can exert more turning force on the screw with less effort than by using an ordinary screwdriver.

The tool is tempered in the following manner: After grinding the edges, heat each one separately to a cherry red color and plunge the beveled part into water, leaving the portion above it hot. Then quickly rub one of the hardened sides bright with a file and watch the colors as they extend from the heated part toward the edge. When a light purple color reaches the edge, plunge the tool into cold water, leaving it until quite cold. The object of lowering the temperature of the edges is to prevent the latter from breaking when the tool is in use. The screwdriver may be insulated by slipping a piece of rubber tubing over it, leaving the ends uncovered.—Electrical Record.

Pat was engaged in helping an electrical worker to shellac some wiring. He was told to exercise great care so that none of it landed on the machines. It was St. Patrick's Day, and some of the boys were kidding Pat because the label was yellow, instead of green. In some manner, Pat dropped the can scattering the shellac in every direction, doing no harm, however, other than the loss of the material.

The boys yelled: "Now you've played hell. You've spilled the beans!"

"Banes, is it? Why, I thot 'twas paint."

Safety in the Engine Room

Prepared by the Engineering Department of the National Safety Council

AN ENGINE ROOM should have at least two means of entrance and exit, each of which should be easy of access and within reasonable view of the engineer in charge. All passageways and exits should be free of obstructions, and doors should open outwardly and should not be so close to operating equipment as to create a hazard. Basements of engine rooms should have exits so arranged that men may not be trapped in the basement.

A sign should be conspicuously posted outside each doorway forbidding entrance except on business.

If entrance ways are kept open for ventilating or other purposes, bars or grates should be placed across the entrance.

The floor of the engine room should be of concrete or abrasive surface to eliminate the slipping hazard. When approach is had to any engine or machine, the non-slipping provision should be emphasized. Frequently inserts or mats of non-slip material are used at these points when the entire floor is not of non-slip material.

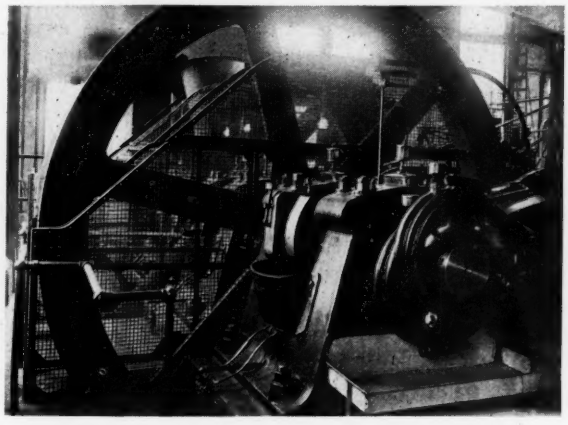


FIG. 1. METHOD OF GUARDING LARGE FLYWHEEL

Guards on Engines

Flywheels should be guarded as follows: Where the guard is not less than 15 in. from the wheel, by a railing, the top of which is at least 42 in. from the floor, with an intermediate rail midway between top rail and floor and a toeboard at least 4 in. high at the base of the railing. Such guards should not be more than 20 in. from the wheel.

Where guard is less than 15 in. from the wheel, it should be not less than 5 ft. high (unless wheel is less than 5 ft. in height, in which event guard need not extend above wheel) and should be a solid guard or a mesh guard with openings not greater than 1½ in. in any direction.

Flywheel guards should be carried over the bearings at the same relative height as the guard on the floor and should be of the same construction as to size of openings in guard.

A disk guard of metal or fiber is considered safe on balance wheels not more than 5 ft. in diameter, where they do not extend through the floor. Such disk guards should be so attached to the wheel as to protect the spokes. When space is left between edge of disk and rim of wheel, to facilitate turning wheel over, it should not exceed 2½ in. in width. When disk guard is used see that keys or other projections in hub or rim of wheel are guarded.

No door or gate should be allowed in flywheel protection, except on gas or oil engines, where such provision may be necessary.

Crank shafts, connecting rods and tailrods should be enclosed by sheet metal or mesh fabric in such a way as to prevent accidental contact with them, or they should be protected by a standard railing at least 15 in. and not more than 20 in. from the moving parts. Any points of railing coming within 15 in. of a moving part should be covered with sheet metal or mesh fabric.

In some instances, oil shields are so arranged as to enclose these parts, thus making additional guards unnecessary.

Care should be taken to guard all other revolving or reciprocating parts or shearing motions where accidental contact may cause injury.

Main bearings which cannot be reached readily from the floor should be equipped with standard stairs having safety treads and railings on the side opposite the flywheel.

All ladders and stairs on engines should be railed, and all staging 6 ft. or more above the floor should have a railing with a toeboard at least 4 in. high at the base of the railing.

When the engine bed is used as a walk, it should be equipped with a proper railing and toeboard.

Flyball Governor Guard

A hemispherical sheet metal or wire mesh basket, strong enough to hold the balls in case of breakage, placed under the flyballs, is a useful guard and is absolutely necessary if the governor encroaches at all upon a passageway or a position occupied by an attendant in the performance of his duties.

Access to Valves

Stairways or stationary iron ladders should provide access to valves—especially emergency valves—which cannot be reached from the floor or other safe place; provided, of course, provision is not made to operate the valve by remote control, from the floor or platform.

Oiling

Installation of automatic oiling systems has done much to prevent accidents in engine rooms, besides effecting considerable economy in operation. Oil is regulated by gravity flow and the residue is caught in containers, and, after clarification, returned to feed tanks. Oilers' platforms and runways are installed in all up-to-date engine rooms, and, if the oiler is properly

instructed in his work and the safety rules of the plant are rigidly enforced, few accidents will occur.

The commonest form of accident in the engine room is caused by the slipping or tripping hazard, and the careless handling of oil is one of the chief contributing causes.

Independent Safety Stops

Failure of the regular safety devices, placed on the engine by the builder, to prevent flywheel wrecks, has prompted the invention of special safety stops and speed limit devices designed to act independently of and supplementary to the regular devices. These special devices undoubtedly lessen the chances of accident and their use is therefore to be encouraged. But it must be borne in mind that they cannot be implicitly relied upon. They consist of complicated mechanism, which generally includes an electrical circuit. It is well to

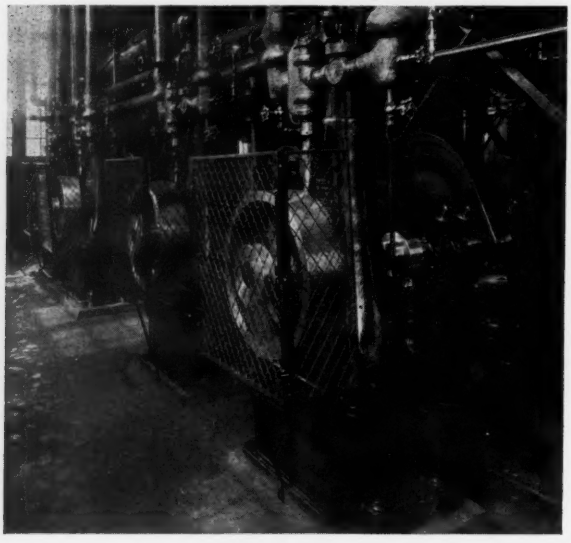


FIG. 2. GUARDS FOR SMALL HIGH-SPEED FLYWHEELS, HINGED TO THE ENGINE BASE

attach them to engines, but the vigilance of the attendants should not be relaxed one particle when they are attached.

Automatic Vacuum Breakers

When condensing engines are liable to be lightly loaded for any length of time, it is especially desirable to provide a safety device that will break the vacuum when the water rises to a certain height in the condenser. If this is not done, the condenser may be flooded and the engine wrecked, should the speed of the airpump slacken.

Safety devices arranged to shut off steam in case the engine starts to "race" should also be arranged to break the vacuum at the same time. Even when the steam is shut off the vacuum is often sufficient to speed up an engine under no load to the point where the wheel is burst by centrifugal force.

Steam Separators

It is important, from the standpoint of economy, that an engine have dry steam. It is further important that no water shall get into the engine cylinder, as the clearances are small and a very little water getting in may result in a cylinder head being knocked out. It is always advisable, therefore, to have a steam separator on the engine supply pipe, placed as close to the engine throttle as possible. The most useful separators are those of the receiver type, that is, having a large volume, preferably 6 to 7 times the volume of the engine cylinder. These receivers should be riveted steel drums. A separator of the receiver type is not only of value in intercepting the moisture in the steam, but also in maintaining an even flow of steam and in providing a reservoir close to the engine, by this means taking up the vibrations due to the sudden stoppage of the flow of steam when the engine valves close, and preventing these vibrations being transmitted to the piping system. Steam flows in an engine supply pipe at a velocity of from 5000 to 6000 ft. a minute, and the alternate starting and stopping of the flow several hundred times a minute is apt to set up serious vibrations. A separator is also valuable in catching bolts, nuts, etc., carelessly left in the steam pipes in erecting new work, and thus saving engines and turbines from damage.

Separators are often so badly neglected that they are a menace, rather than safeguard, to the engine. Usually the separator is connected with a trap which is intended to drain it automatically, but which is often out of order. All steam separators should be covered with some good insulating material. A separator presents as much surface as a considerable length of steam pipe, yet it is not uncommon to find separators bare. Gage glasses on separators should be considered as important as those on the boilers.

Engine Piping and Drains

The ends of cylinder or exhaust pipe drains should be where they can be seen and where they cannot get a water seal. The exhaust pipe drains should not be less than one-quarter the diameter of the exhaust pipe. In condensing practice, care should be taken that these pipes do not connect to the condenser or exhaust pipe at such a place as will make it possible for water to be drawn into the cylinder.

The practice of bringing the drain pipes from both ends of the cylinder to a tee is dangerous. The reason is that the water forced out of one end may not drop down the tee-connection, but be carried by and up the other pipe into the cylinder in front of the advancing piston.

All steam engines should be equipped with explosion diaphragms or relief valves. Pop valves should be placed on receivers of compound engines to prevent a dangerous rise of pressure due to the high-pressure valve stem breaking, or other cause. The admission of high-pressure steam to the low-pressure cylinder has been the cause of engine "racing," and an explosion of its flywheel by centrifugal force.

A trap or other means should be provided to remove condensation from the receiver or cross pipe of a compound engine, and it should be blown out each day, in order to be sure that there is a clear passage through it.

Piping in General

Steam pipes should always be of wrought iron or

steel. Cast iron should never be used for this purpose. The use of copper pipe is also inadvisable.

"Full weight standard" pipe should be used for pressures up to 125 lb., and "full weight extra heavy" pipe for pressures above 125 lb. Cast iron "standard" fittings should be used only for pressures below 100 lb., "medium extra heavy" for pressures from 100 to 150 lb., and "extra heavy" over 150 lb. Malleable iron fittings are better than cast iron fittings, and cast steel fittings are better yet.

Steel pipe bends of long radius are preferable to cast elbows of short radius, as they give the piping system greater flexibility and so enable the expansions and contractions to be borne better, besides which they lessen the vibrations and make the steam-flow easier. It is always best for steam piping to turn corners by long and gentle curves, avoiding right angles, if possible. The pitch of all pipes should be in the direction of the steam-travel.

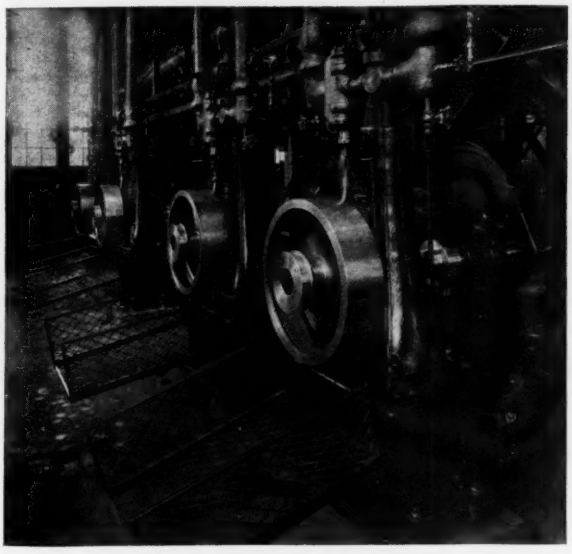


FIG. 3. SMALL FLYWHEEL GUARDS SHOWN OPEN

In making pipe joints, screwed or threaded joints are suitable only for small pipes and low pressures. For pressures over 150 lb., joints in pipes less than 5 in. in diameter may be of the screwed type if the end of the pipe is peened or rolled into a recess in the face of the flange, to prevent leakage and loosening of the pipe in the flange, but joints in pipes of over 5 in. had best be of the welded type or the Van Stone type.

Gate valves are preferable, as a rule, to globe valves. Large valves, that is, over 6-in., should be provided with bypasses. These bypasses will enable the valves to be opened easily by equalizing the pressure on the two sides, will enable steam to be admitted gradually to the cold end of the line and warm it up gradually, thus distributing the expansion stresses more uniformly, and will prevent water hammer.

All pockets and dead ends should be supplied with drip pipes, so that all condensation can be taken care of. Do not allow any dead lengths of pipe to stand over night with the steam on them, if it can be avoided.

Wherever there is a rise in the main, a drain should be tapped into the lowest point of the main just below the rise. The mains and all important branches should terminate in a drop-leg, into which a drain is tapped.

Valves should be so located, if possible, that they cannot form water pockets when either open or closed.

Steam pipes should be blown out at intervals, to clear them of any debris that may have accumulated in them.

All separators, steam reservoirs and drop-legs should be provided with gage glasses, which should be kept in good working condition.

It is advisable to avoid long steam headers intermediate between boilers and engines. Direct connections are to be preferred from every standpoint. Steam headers have caused disastrous accidents.

Short and stiff pipes for connections between boilers and engines are also to be avoided. Some engines have enough movement on their beds to cause the breakage of elbows and tees in short and stiff pipe connections. Proper provision for more or less movement should be made. If the engine room roof is too low to permit the proper disposition of piping, "dog houses" should be arranged so that proper piping may be put in.

What Shall We Read?

By J. B. Dillon

MANY people are worried, because, as they state, they want something wholesome to read, and are undecided what to select, due to the diversity of opinion existing among those to whom they mention the matter.

First of all, an adult should inspect the daily paper, but that does not mean to read every item therein; merely those that are worth reading, to keep posted as to world progress.

After the newspaper a man should read the best trade journal devoted to his calling, and not only read it, but study many items therein; then file them for future reference..

Whenever I hear anybody say that he is unable to find good reading matter, I am forced to conclude that he reads any and everything, just because it is late stuff.

To get out of that rut, and to find a selection of good, wholesome reading, write to the Bureau of Education, Home Study Division, Washington, D. C., and ask them to send you their complete lists of readings. It is free, no stamps to be enclosed. Take up the course that seems best suited to your taste and you will find contentment. You will read some of the master work of all times; writings that probably never will be eclipsed—if equaled.

When you are thus schooled, you will be able to decide for yourself what is fit and what is unfit. You will get an uplift that you never dreamed was possible. You will realize why certain books are called classics, and you will find that, regardless of the jokesmiths who say that classic means something that nobody understands, that classic means class and such class as is worth while—not dissertations that are not understandable, as some would have us think. In brief, you will have an intellectual awakening.

IT'S ONLY his victims that call the "sharp" man shrewd.

Ammonia in Refrigeration

How Utilized in the System. By A. G. Solomon

IN the ammonia compression system of refrigeration, heat is taken from the substance cooled and delivered to the water that flows over the coils of the ammonia condenser. The ammonia is simply sent to one part of the system, where it receives its load of heat and then sent to another part of the system, where the heat is unloaded. That is all there is to the operation of a refrigerating plant. But to have the entire system work in unison and perform its duty in an efficient and economical manner requires that the operating engineer know something about ammonia.

Just what anhydrous ammonia is and how it is made does not concern us. We are satisfied as long as the ammonia that we put into the system is pure and free of moisture. It is the engineer's duty to keep the ammonia as pure and clean as possible.

To understand fully the changes that the ammonia undergoes, the engineer must familiarize himself with the "Properties of Saturated Ammonia Vapor." A careful study of this table will give more true knowledge of refrigeration than anything else that I know of.

As the ammonia travels a complete cycle, its state or form is changed four times. It is a liquid at one time, then saturated vapor, and next superheated gas, and again a saturated vapor. As a liquid it leaves the ammonia condenser and goes to the liquid ammonia receiver. From the receiver it passes through the liquid line and reaches the expansion valves. At this point it is believed by many that the ammonia is changed into a vapor or gas; but this is not the case. Nothing but liquid ammonia should pass through the expansion valves, as liquid alone is the substance that takes up heat from whatever is to be cooled.

Then it is plain that the evaporating coils are supplied with liquid that is evaporated by the heat surrounding the coils.

The liquid ammonia, having taken up enough heat units to cause vaporization, passes from the coils and to the ammonia compressor.

Leaving the compressor, the ammonia is in a superheated state. The degree of superheat will depend on the type of machine and on the operating conditions. This superheated gas then goes to the ammonia condenser, where the superheat is given up to the circulating water and the ammonia assumes a saturated state once more. Then liquefaction takes place and the cool liquid begins the cycle again.

The temperature at which the ammonia assumes a liquid form in the condenser is just as easily determined as is the temperature at which it evaporates in the direct expansion coils.

In the ammonia condenser, the superheated gas must be changed into saturated vapor before liquefaction begins. Or, rather, the liquid begins to form as soon as the temperature of the ammonia reaches that point at which pressure and temperature are functions of each other.

As an example, we will consider a system where the condenser pressure carried is 185 lb. gage. At this pressure the superheated gas will be changed into saturated vapor as soon as the temperature is lowered to 95.5 deg. F.

Now, that there may be no confusion about this, the following statement must be taken as a plain and true fact: "When considering ammonia in a saturated state, pressure and temperature are functions of each other;" that is, at a given pressure there is a certain temperature at which the ammonia remains in a saturated state.

Take superheated gas (no matter what the amount of superheat) at a certain pressure and lower the temperature till the gas changes into a saturated vapor, and the temperature at which this change takes place will be the temperature of saturated ammonia vapor at the given pressure, as shown in the ammonia tables. Increase the pressure, and the temperature will also be higher; lower the pressure, and the temperature will be lower.

In our example we will raise the pressure from 185 to 210 lb. This will change the temperature where the superheated gas turns into saturated vapor to 103 deg. F. This pressure-temperature relation is in no way affected by the temperature of the cooling water. Neither is it affected by the amount of cooling water.

If the condenser is supplied with sufficient water of a low temperature, it is reasonable to expect a low condenser pressure. With this low condenser pressure, there must be a low temperature at which the ammonia turns to liquid.

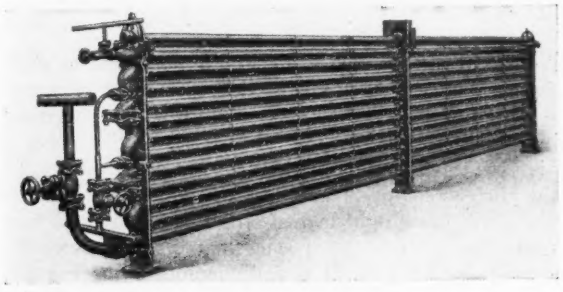
Now, we see that the pressure and temperature are closely related at the point where the superheated gas becomes saturated vapor. The condensing water must be at least a few degrees colder than this temperature, or liquefaction would not be complete. But no matter how cold the water may be, the temperature of the ammonia when in the saturated state must be that which corresponds to the pressure as given in the "Ammonia Tables."

After the superheated gas which entered the condenser has been cooled enough to change it into saturated vapor, the liquid state begins to appear.

At the outlet of the condenser coils, the liquid should have a temperature as near that of the condensing water as is possible. In the double-pipe type of condenser, this equal temperature is nearly realized as the incoming cold water comes in contact with the outgoing liquid. In the more common type of atmospheric condenser, the liquid temperature is several degrees higher than the water temperature, as the water is heated by first coming in contact with the top pipes that contain the superheated gas.

The accompanying illustration shows a coil of a "counter-current" ammonia condenser. In this, the superheated gas from the compressor enters the bottom pipe. As the liquid is formed, it passes to the liquid line through the small bent drip pipes that are provided at different heights of the coil. This type of condenser will deliver the liquid to the liquid line at a temperature of but a few degrees above that of the coldest condensing water.

Now, we must not confuse the liquid temperature with the temperature of saturated vapor.



TYPICAL 12-PIPE COUNTER-CURRENT AMMONIA CONDENSER

After the ammonia is in the liquid state, its temperature can be lowered to any point, regardless of pressure. This low temperature liquid is made manifest in plants where liquid recooling is done by such means as a double-pipe liquid ammonia cooler. This cooler is operated the same as a brine cooler, the only difference being that liquid ammonia instead of brine is circulated through the inner pipe.

With a good charge of ammonia in the system and under good operating conditions, the temperature of the liquid is lowered to within from 10 to 15 deg. of the temperature of the ammonia in the evaporating coils. The great advantage of this precooling is evident in a plant where the evaporating coil surface is small compared with the capacity of the other parts of the system.

One point that must always be remembered is: Do not allow the temperature of the liquid to be raised after it leaves the condenser. Every heat unit absorbed by the ammonia between the condenser and the expansion valve is a loss. Insulate the liquid lines if they pass through warm places. Insulate the liquid receiver if it is located in a hot engine room.

We will take it for granted that after the liquid leaves the condenser it is neither heated nor cooled, but reaches the expansion valves at the temperature at which it is cooled in the condenser. At 185 lb. pressure and cooling water at 75 deg. F., the liquid can be admitted to the evaporating coils at a temperature of 85 deg. without any trouble.

Now, if the temperature of the ammonia in the evaporating coils is zero, and the ammonia passing through the expansion valve is 85 deg., there is plainly a difference of 85. This warm liquid cannot do any work as a heat absorber until its heat is first given up. From every pound of 85 deg. liquid admitted to the coil, 85 B.t.u. must be removed by the ammonia in the coil.

One pound of ammonia evaporating under a pressure of 15 lb. requires 572 heat units to change the liquid to a saturated vapor. In plainer words: One pound of liquid in an evaporating coil will absorb, or take up, 572 B.t.u. when the back pressure is 15 lb. gage. But, as the ammonia has a temperature of 85 deg. when it enters the coil, the total amount of heat absorbed from the brine or produce is 572 minus 85, or 487 B.t.u. This looks like a very evident loss. This liquid heat must be given up at some point of the system and it will depend on the individual plant whether it is best to remove the heat by liquid precooling or in the evaporating coils.

If the compressor capacity is greater than what is necessary for the amount of pipe surface in the evaporating side of the system, the precooling of the liquid will have the same effect as the installing of more evaporating coils.

The precooler should be located between the liquid receiver and the expansion valves, and the cooler and the connecting lines must be well insulated to prevent the reabsorption of heat.

As a rule, from 5 to 10 heat units can be taken from the liquid by the installation of a water jacket around the liquid line and circulate the coldest available water through the jacket.

Every degree that the liquid temperature is lowered by other means than by the evaporation of ammonia is a direct gain.

After the liquid has entered the evaporating coils and its temperature is that which corresponds to the temperature of saturated vapor at the pressure existing in the coil, the actual useful work begins.

Every pound of ammonia will absorb a certain number of heat units, and this number is different for different pressures. The higher the pressure, the less heat required to cause evaporation. At atmospheric pressure, the number is about 592; while, if 30 lb. pressure shows on the back pressure gage, the number of heat units is only 558.

After the liquid has taken up the amount of heat to cause its vaporization, it is what we may call loaded to capacity. It will carry no more heat without changing its state. Superheating begins at this point. Just as soon as the vapor is heated, even 1 deg. above the saturated temperature, it is superheated gas. The so-called flooded system is simply an arrangement of the evaporating side of the system whereby the superheating of the ammonia in the coils can be prevented easily.

Superheated gas does not absorb its share of heat, so any part of an evaporating coil containing this gas is almost useless pipe. There is, of course, some heat passing from the brine or air and entering this gas; but the rate of transfer is so small that it is considered

loss when compared with the heat that would pass into the coil if there were any liquid present.

Every foot of coil should contain ammonia in a saturated state. Superheating should not take place until the vapor has entered the suction line on its way to the compressor. The degree of superheat must be kept as low as possible, as the superheating increases the volume of the gas that must be handled by the compressor. As weight of ammonia handled is what determines the capacity of the compressor, it is readily seen that the compressor must discharge more gas at a high temperature than at a temperature close to that of the saturated vapor.

A thermometer should be placed in the suction line, close to the compressor, and the temperature of the gas entering the compressor should be kept from 1 to 5 deg. higher than the temperature of saturated vapor at the back pressure carried. This amount of superheat will prevent unevaporated ammonia entering the compressor.

If the system consists of direct expansion coils and ice or brine coolers, there should be a thermometer in the suction line from each set of coils. This will be a guard and will show that each and every part of the evaporating side of the system is doing its full duty.

The expansion valve on one coil can be open wide enough so that liquid will pass entirely through the coil and enter the suction line. Other coils that are connected into the same suction can send enough superheated gas into this suction so that the liquid from the first coil will be evaporated to such an extent that the thermometer close to the compressor will show a good working temperature. In cases of this kind, temperature readings are misleading, if not entirely useless. Have thermometers in all branch suction lines and see that the ammonia leaving each set of coils is in a saturated state.

Now the ammonia enters the compressor and further superheating takes place at once. The compressor walls, piston and valves are really hot when compared with the vapor that is in the suction line. This heat of the metal causes superheating of the vapor immediately upon its passage through the suction valve.

Where cylinder cooling by liquid injection is not resorted to, the temperature of the ammonia at the end of the suction stroke is often as high as 60 deg.; and in a great many cases it is even hotter than this. Amount and temperature of jacket water and speed of the machine will cause different degrees of superheating of the gas entering the cylinder.

This superheating, and therefore reducing of weight for a given volume will account, to a great extent, for the actual volumetric efficiency of the ammonia compressor.

One point is certain and that is: The actual amount of ammonia sent to the ammonia condenser by the compressor cannot be calculated by taking the weight of saturated vapor at suction pressure as a basis for the calculations.

To illustrate: At about 15 lb. gage suction pressure, the temperature of saturated vapor is zero. One pound of this vapor will occupy 9.19 cu. ft.

Now we will still maintain the same pressure, but will consider the ammonia as it really is in the compressor at the end of the suction stroke. The temperature will be taken as 50 deg. instead of zero. At this temperature 1 lb. of the gas will occupy 10.41 cu. ft. This will make clear some little matters that have been somewhat hazy to the minds of many.

Now the ammonia leaves the compressor as a superheated gas and goes to the ammonia condenser, where the heat is removed by the circulating water, liquefaction takes place and the ammonia begins its round once more.

Refrigeration Machinery Lubrication*

Characteristics of Oils Most Suitable for Use in Compressor Cylinders; Oil Extractors

IT SHOULD be noted that only pure mineral oils of at least zero pour test should be used in the cylinders of an ammonia compressor. These oils can be obtained with a sufficient range of physical properties to lubricate satisfactorily and efficiently all ammonia compressors working under reasonable conditions. Mineral oils are the most neutral, and a pure straight mineral oil well refined has been found to be the most suitable for this class of work. Compounded oils of any kind should be avoided because of the tendency of animal and vegetable oils to solidify at comparatively high temperatures. Acids which develop in compounded oils also attack the walls of the compressor cylinder and have a detrimental effect upon the ammonia gas.

Insofar as the lubrication of the compressors themselves is concerned, viscosity is of primary importance. Condition of the cylinder, piston rings and valves determines the viscosity of the oil that should be used, as it is essential that the oil should form a seal and maintain perfect compression. For cylinders which are in good condition a light bodied oil will prove satisfactory. Where the cylinders are somewhat worn or scored a medium bodied oil will usually maintain the required seal. In cases where the rings and cylinder are badly worn or scored it may be necessary to install a heavy bodied oil to insure efficient operation. Generally speaking, horizontal machines, due to the position and weight of the piston, require an oil of heavier viscosity than the vertical type, and as most of the horizontal compressors are double acting lubrication of the piston rod should be taken into consideration.

As was mentioned before, it is doubtful if the temperature of the oil in the compressor is ever raised much above 250 deg. F. As all high quality oils have flash points well above 300 deg. F., it would seem that the question of flash might safely be disregarded in selecting oils for compressor lubrication.

While oils having the characteristics just discussed will satisfactorily lubricate the compressor cylinder, requirements of other parts of the plant frequently make necessary the use of an oil having other physical characteristics. There will always be some vaporization of oil due to the heat of compression no matter how high the flash point may be, and this vapor will be carried out of the cylinder with the compressed gas. As refrigerating systems are closed cycles this oil is bound to condense and accumulate upon the colder parts of the system which are the condenser and expansion coils.

Probably no one item in the operation of a refrigera-

*Continued from page 484, May 1 issue.

tion plant so vitally affects economy as the accumulation of oil upon the coils and yet it is amazing how few operating engineers take this problem seriously. A prominent authority has asserted that a film of oil 1/100 in. thick has the same heat resisting properties as a layer of boiler scale 1/10 in. thick and a steel plate 10 in. thick. All oils when sufficiently cooled become thick and at certain temperatures cease to flow. Unless the oil reaching the condenser and refrigerating coil has an extremely low pour test it is bound to accumulate upon the walls of the coils and prevent the effective transfer of heat.

To prevent this condition, an oil used in a refrigeration compressor should have at least a zero pour test, so that any oil getting into the coils may be carried along with the ammonia without congealing upon the walls and seriously affecting the efficiency and capacity of the plant. Natural low pour test oils contain no paraffine wax, and, consequently, no trouble from this source will be experienced when they are used. Before oils made from wax-bearing crudes are used on an ammonia compressor it should be determined that the wax has been removed to such an extent that no evidence of its presence is seen after the oil has been exposed to the lowest temperature in the system. Any operator can make a test to determine the suitability of an oil for his particular work by immersing it in the brine for some time. If it flows readily upon removal it is quite suitable, if not, it should be rejected.

Oil Extractors

An essential appliance in any refrigeration plant is the oil extractor, of which there may be several. The principal extractor should be placed between the compressor and the condenser although advantages will be secured by inserting smaller extractors at the lowest points of the condensing and refrigerating coils. Efficiency will always be promoted by the use of oil extractors no matter how high the quality of the lubricant may be. Complaints are frequently made that the extractor does not function properly and often extractor troubles are charged to the oil being used. In nine cases out of ten when the oil is not removed by the extractor the difficulty is due to the extractor being placed too close to the compressor, at which point the gases are too hot to permit the oil to condense. When the extractor is located close to the condenser the oil will reach it in a condensed form, and, as a result, can be more easily removed. Oil extractors should be of ample size so that the velocity of the gas through them shall not be too high to permit of complete separation.

Location of the oil extractor between the compressor and the condenser and the efficiency of its operation have an important bearing upon the character of the oil selected. If conditions make it necessary to place the extractor near the compressor, an oil giving little evaporation, namely, a high viscosity oil should be used. On the other hand, due to the opportunity which the vapor has to condense, a lower viscosity oil may be used successfully when the extractor is placed some distance from the compressor. Provision should always be made to draw oil from the bottom of the liquid receiver in which it frequently accumulates in considerable quantities. As the oil has a higher specific gravity than liquid ammonia, it naturally settles to the bottom of the receiver from whence it may be drawn and passed through purifying devices.

Oil taken from the extractors and receiver may be recovered by installing an ammonia distilling apparatus, which has the dual advantage of purifying the charge of ammonia and of recovering the lubricating oil without interfering with the continuous operation of the plant. Care should be taken in handling the distiller to prevent too rapid evaporation, as this causes boiling over and the loss of a large proportion of oil back to the suction line. After all the liquid ammonia has been evaporated and returned to the suction line of the compressors, the oil can be drawn from the bottom of the still, using suction pressure for the purpose. The oil removed will contain some water vapor and should be put aside until this has freed itself from the oil. Maintaining the oil at about 150 deg. F. will assist this operation materially. The oil is then ready to be filtered.

It is advisable to use a separate filter for this work, the size and type of filter to be used depending upon the size of the plant and the amount of oil to be handled. The oil recovered from the still, after careful filtering, will again be suitable for the lubrication of the ammonia compressors provided the original oil used on the compressors is of good quality and properly selected.

A record should always be kept of the quantity of oil taken from the extractor, and this should be compared at regular intervals with the amount of oil fed to the compressor. Any great difference should be investigated at once. The film of lubricating oil can always be removed from the condenser coils by discontinuing the cooling water from one strand at a time. When the pipes become hot the oil will thin down and run off into the receiver. When the refrigerating coils become fouled with congealed oil the accumulation may be removed by reversing the system and forcing hot gas through the coils. The same result may also be obtained by blowing out the coils with steam followed by air to remove the moisture.

Temperatures play an important part in the efficient operation of any refrigerating plant and to get the highest efficiency it is necessary to know what the temperatures are in the different parts of the system. This is also the most important consideration in selecting a lubricating oil for this class of work. Where thermometers are installed in both the suction and discharge sides of ammonia compressors the selection of a lubricating oil becomes a simple matter.

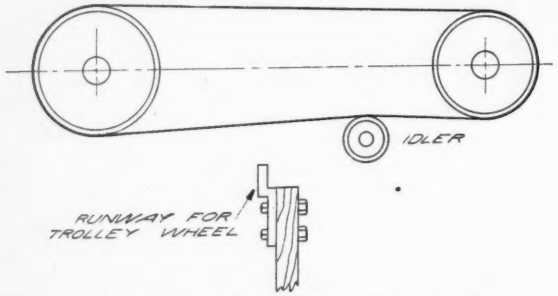
The ideal refrigeration oil should remain a fluid at the minimum temperature in the evaporating side of the system and not undergo any chemical change at the maximum temperature of the compressor discharge. It should also have sufficient viscosity at the working temperature of the compressor parts to lubricate properly and to form a seal for the piston rings and valves.—Lubrication, published by The Texas Oil Co.

U. S. Civil Service Commission announces an examination, June 23, for mining draftsman, for both men and women, to fill a vacancy in the Bureau of Mines, Pittsburgh, Pa., at $1200 a year, and future vacancies requiring similar qualifications throughout the United States, at this or higher or lower salaries. Apply for Form 1312.

Belt Transmission Problem

IT WAS necessary to drive a secondary line shaft from the main line shaft by a belt. Arranged in the usual way, the belt would run into a trolley runway. To pass the belt over this an idler was placed above the runway, as shown in the accompanying illustration, high enough so the trolley wheels could pass under the belt. The centers between the two pulleys are a long distance apart, so when the belt got a little slack it would flop up and down, and should any of the trolley wheels be under the belt, it would knock them off the runway; besides, it ruined the belt.

The belt had to be shortened frequently on account of the flapping, although it pulled the load without slipping. To avoid this trouble, we have decided to equip the idler so that it can be raised to prevent flapping of the belt whenever this gets a little slack.



METHOD OF KEEPING LONG BELT CLEAR OF TROLLEY RUNWAY

With this arrangement it will not be necessary to shorten the belt as often as now.

When moving a machine to another location in the factory, it was found that a different size pulley was required on the line shaft than was formerly used, due to the fact that the line shaft did not run at the same speed as the other. There was an old wood split pulley in stock of the right size, so this was put in place. In starting up the machine it was noticed that the belt would not remain on the tight pulley when shifted there. At first I thought the machine was not in line and level, but this was not the trouble. In looking further I found that the face of the pulley driving the machine was crowned, causing the belt to travel to the center of its face, hence the reason it would not stay on the tight or loose pulleys on the machine. There being no other pulley on hand I decided to remove the crown quickly in the following way: The belt was thrown off the pulley and engine run slowly; then by holding a rasp or wood file on the face of pulley the crown was removed, not entirely, but sufficiently so that the belt would remain on the tight or loose pulleys on the machine.

In another instance a machine in a factory plant was to be belt driven from a line shaft. There was a wood split pulley on hand of the proper diameter, but the face was too narrow. I had about decided to order a new pulley when I noticed a pulley on the line shaft which was much too wide for the belt it was driving. I found it was just the thing as to diameter and width of face to drive the new machine, while the pulley we had on hand was just the thing for the other drive. We made an exchange, so it was not necessary to order a new pulley for the new machine.

There are machines where a few revolutions more or less make little difference and frequently in a case of this kind a pulley a few inches larger in diameter could be used, saving the price of a new one. Some time ago I installed a number of extractors in a laundry plant. To get the speed the machine called for, a 22-in. diameter pulley was needed. There were a large number of used pulleys on hand in the plant, but none 22 in. in diameter. There were, however, some 24-in. in diameter, so I decided to use these in place of 22-in. After the extractors were in operation, one of the operators reported that these machines ran much better than the others in the plant which were of the same type and make and ran at the speed the plate called for where 22-in. pulleys were used.

In this case the price of two new pulleys was not only saved, but the apparatus ran much better.

H. A. JAHNKE.

Comments on the Middle Sheet and Fire Cracks in a Three-Course Return Tubular Boiler

ON PAGE 491 of May 1 issue, I. B. Leavitt says that the principal reason for placing the middle course of a three-course boiler inside the others is for strength.

It is then twice the plate thickness less in diameter than if placed on the outside of the two ends. He says also that it has been found from experience that a vessel subjected to pressure tends to stretch or expand in the middle first, and that by having the middle course inside the others that section of the boiler is made stronger.

In my article, April 1, page 401, I said that my reason for putting the middle sheet inside was to prevent fire cracks in the front end of this sheet, and I still believe that is one of the main reasons; but there are other reasons, as follows:

Usually the manhole is placed in this sheet, and, as this weakens the sheet to a certain extent, we place the sheet on the inside to give a stronger section for the manhole. It also does away with a scale pocket over the intense heat of the fire.

The inner course is the strongest, due to a smaller diameter, with ½-in. plate, 100 lb. pressure and 60-in. diameter boiler.

This gives 30-in. radius; 30 × 100 = 3000 lb. tending to rupture along the longitudinal joint for one running inch.

By placing the middle sheet inside, we have a 59-in. diameter, a 29½-in. radius; 29½ × 100 lb. = 2950 lb. on middle sheet. By placing on the outside, we have a 61-in. diameter, or 30½-in. radius; 30½ × 100 lb. = 3050 lb. on middle sheet, which shows why the inside course is the strongest.

In regard to fire cracks, that boiler inspector will tell you that fire cracks will develop at the first girth seam, if exposed to the fire, if scale is permitted to gather on this seam, or if the drift pin was used too freely.

I should say that if the first girth seam was exposed to the heat from the fire on a straight flush front boiler, that the fire protecting brick have fallen down, and the gases and heat will short circuit (if the smokebox is made of brick), while, if there is an extension sheet to form the smokebox bolted onto the head, it will burn through. Of course, you would not try to run with a boiler in this condition; but if you did, and kept opening and closing the firedoor, there would be an inrush of cold air, which would be heated some before it struck the edge of the plate, still there would be a great difference of temperature, and there would be danger of forming fire cracks.

If we had enough scale on the inside to form fire cracks, I should expect that my boiler would be bagged first. On old boilers, where drift pins were used, they have been the cause of most fire cracks; but on modern construction a drift pin should never be used.

W. N. L.

An Unusual Boiler

In reply to J. Raia's letter in the April 15 issue, I give below some details of an unusual type of boiler, which if successful would go a long way in saving coal.

The boiler consists essentially of 11 tubes, 12 in. in diameter and 7 ft. 6 in. long with walls 0.42 in. thick. These tubes, which contain 298.8 ft. of heating surface, revolve at 375 r.p.m., keeping the water in contact with the heating surface and the steam in the center.

There is at present an installation of this type driving a 600-hp. turbine in a sugar mill, delivering 13,200 lb. of steam at 618 deg. F. and 700 lb. pressure.

E. G. M.

Castor Oil as Belt Dressing

According to the letter of N. G. Near, appearing on page 480 of the May 1 issue, he evidently does not agree with H. W. Rose as to the use of castor oil on belts. I must, however, say that I cannot say too much in its favor.

In one instance, in particular, I had considerable trouble with a belt on which so-called dressing had been used. It was necessary to keep this belt so tight that striking it with a hammer would seem like hitting a hard board and when not retained at such a great tension, it could not be made to ride its pulley properly.

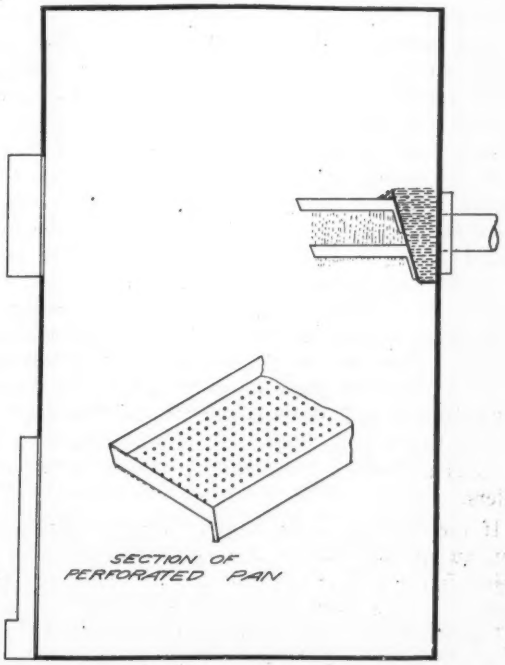
After many vain attempts to continue the use of this dressing, I decided to change to castor oil. I scraped off all of the old dressing and then, each night, for a week or so, applied a little castor oil. After three weeks of this treatment I had the finest working surface on both belt and pulley imaginable. It was not in the least sticky, but just like the bottom of a pair of rubbers, and this belt, which formerly had to be run so extremely tight, then ran with a sag of 6 in. and no slip whatsoever.

N. G. Near claims castor oil does not prevent slippage. This, however, as evidenced by the foregoing, has not been my experience, and, after 2 yr. use of castor oil, I have noted no decomposition, of which Mr. Near speaks. The belt is soft and pliable and, no matter how great the sag, it continues to carry its load.

A. Waldron.

Increasing Temperature of Heating Returns

During the winter season, about 60 per cent of our feed was made up of heating system returns which came back at 150 to 160 deg. because at times it was necessary to use injection water on the vacuum pumps. The returns were being brought into the side of the heater and hence received very little reheating with the result that our temperature ranged about 190 deg. It was impracticable to enter the water in the top of the heater, because the equipment was already being loaded to capacity.



SHOWING APPLICATION OF SHEET IRON TRAYS IN FEED WATER HEATER

It finally occurred to us that we could accomplish some heating action on the returns by breaking them up, as they entered the side of the heater and this we accomplished by installing two sheet iron trays, perforated, as shown in the illustration. This little scheme resulted in boosting the feed temperature up to 200 to 208 deg. with a consequent saving in fuel.

M. A. Saller.

Filing Clippings

In the March 1 issue, I read an article on filing clippings on different subjects. I have a convenient system somewhat different from that described, which consists of a letter file of blue cardboard, indexed from A through the alphabet. In this letter file are used gray blank folders, headed by the subject under which the clipping is filed belonging to that subject. The blue indexed cardboard enables me to turn quickly to the subject to which I wish to refer, and the folder containing the subject can easily be found.

For instance, I wish to save clippings on treating feed water for boilers, synchronous motors and coal. I head one blank folder with "Water Treating," one with "Synchronous Motors," one with "Coal." Sometimes I wish to save two articles which are printed on the same sheet. If I file the sheet under one head, I lose the other article. Assume there are two articles, one on "Water Treating" and one on "Synchronous Motors," printed on the same sheet. To save both articles, I file the sheet in the folder labeled "Water Treating" and in the folder labeled "Synchronous Motors" I write on a blank sheet "Synchronous Motors" (Found in folder labeled "Water Treating" marked No. 1). If I wish to read up on synchronous motors, I am referred to the article found in "Water Treating," and all other folders containing articles on synchronous motors.

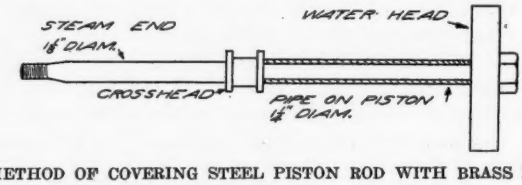
Also, sometimes there are three articles distributed throughout two printed sheets, which I wish to file, the middle article being divided between the two sheets. Assume that the first article is on water treating, the divided article is on synchronous motors and the last article is on coal. I would file the first sheet on water treating in folder marked "Water Treating," and the second sheet containing the article on coal in the folder marked "Coal." At the bottom of the divided article on synchronous motors on the first sheet, I would write "Coal" No. 2, showing that the rest of the article on synchronous motors can be found in the folder marked "Coal." Then in the folder marked "Synchronous Motors" I write on blank sheet, "Synchronous Motors" (artiele found in folder marked "Water Treating" No. 2). By this scheme I can refer to the article on synchronous motors even though it is found in two other folders.

If the files are cared for and all good articles are kept, an engineer can in a very few hours cover any subject fairly well. Some time ago the writer was called upon to write a short paper on "Efficiency in the Use of Transformers." By referring to the folders marked "Transformer Installations," "Transformer Efficiency," "Transformer Connections" and "Transformer Losses," the subject matter was easily gotten together. Also, some time ago the question arose between the chief engineer and superintendent as to the cleaning of the evaporating coils in a freezing tank. The chief brought forth several books showing that the coils should be blown out with steam and air every year for good working conditions. The files were referred to, and the latest practice on cleaning coils was read—never to touch the coils with hot steam unless they showed to be badly coated with oil, and the efficiency of the tank low. The coils were examined and no coating of oil was found. The files in this case saved the company the expense of cleaning and repairing leaks.

There is no estimating the value of good clippings filed away where they can be found when they are wanted. W. A. Darter.

Boiler Feed Pump Repair

The accompanying illustrations show the method we used to repair a worn hot water pump piston rod. The rod was originally 1⅛ in. in diameter, but we filed it down to a good fit inside of a piece of 1-in. brass pipe. The pipe butts against the crosshead and is of such a length that the water piston clamps it tightly in place.



METHOD OF COVERING STEEL PISTON ROD WITH BRASS PIPE

The diameter of the rod is now 1¼ in., so it was necessary to increase the size of the stuffing-box. The gland had a brass bushing ⅛ in. thick. This was removed and the stuffing-box hole was enlarged to 1¼ in. to fit the repaired rod. L. T. McCoy.

Getting By; Cause of Bag

I have been reading "Engineers' License Law," by M. W. Cartee, on page 444 of the April 15 issue.

His line of logic appeals to me, and it should appeal to all readers of this magazine. I hear every day about some engineer who has "got by" the examiner, meaning that he has obtained the sought-for license without overexertion on his part.

Not long ago, it came to me, unsolicited, that an engineer had obtained the highest possible license who had never really had charge of any engine plant over 15 hp., though he had had charge of a small battery of small boilers.

This "getting by" does not appeal to me to any great degree.

I believe the candidate should be qualified by experience, as well as book knowledge. I don't mean theory, because book knowledge is not always theory.

As Mr. Cartee says, "Education should come first," because education places the engineer on a plane with the man higher up; education many times eliminates the grease spots, as it were. Education teaches the engineer to have his face and hands clean when he is summoned to the office to meet—he doesn't know whom.

Education commands respect!

Mr. Cartee says, "works next." Yes, education of itself is not all that is necessary. Work really does have a prominent place in engineering, though, when a man has finally worked to the chief's berth, his mule work should be over and his head work increase.

Does a first-class chief grab a monkey wrench, a crowbar or some other tool when a break occurs, and have the other seventeen occupants of the power plant

as an audience, or does he give directions and have the said seventeen do the monkey wrench work?

Part of the education previously mentioned consists of keeping your hands in your pockets at certain times, even though they may itch to get busy.

I belong to the N. A. S. E. and have considered it one of the best investments I ever made.

On page 446, "What Caused the Bag?" has held my attention. J. A. H. does not state whether the 19 amp. is on a single-phase or one leg of a three-phase, but it is a safe assumption that if 19 amp. = 75 kw.,

$$170 \text{ amp.} = \frac{170}{19} \times 75, \text{ or } 671 \text{ kw.}$$

As 671 kw. would be about 894 theoretical horsepower, and, in practice, about 980 indicated horsepower, I should think that the poor little engine's totaling only 250 hp. would bag along with the boiler!

I have known of a 6-ft. boiler of the horizontal tubular variety doing 500 hp. under high forced draft, but I never heard before of one single 150-hp. boiler supplying steam for simple engines doing approximately 1000 hp.

I judge that 70 amp. is nearer the correct reading. This would be about 410 i. hp.

At this load the steam consumption would probably be somewhat high and it is safe to say that one boiler of 150 rated horsepower could not carry the load.

It would not take much oil on the sheet to cause a bag if the boiler was steaming hard enough to operate the engines doing over 400 hp. TOM THUMB.

Preventing Boiler Explosions

IN THE issue of May 1, C. S. Tompkins comments on a boiler explosion and the action of the boiler inspector.

As the days of mysterious explosions are past and it is now a question of temperature, pressure, corrosion, cracks, defective material or design, the readers appreciate articles giving the reason for certain conditions or occurrences. It would be of interest to the readers if it were shown why this boiler exploded.

The boiler being 66 in. in diameter, 7/16-in. plate, the half sheet repair part having the longitudinal seams of lap construction double riveted; they would doubtless have an efficiency of from 70 to 71 per cent. Assuming 70 per cent joint efficiency, the bursting pressure would be 510 lb.

It should be noted in the A. S. M. E. Code that the paragraphs 187, 188 and 189 all apply to the construction of new boilers only and not to existing installations.

This boiler is shown to be 15 yr. old, therefore should not be considered under the rules intended for new boilers, but should be considered under Part II—Existing Installations, of the A. S. M. E. Code.

Care should be exercised, when referring to the Code, that the part applying to the particular kind of boilers, or proper conditions, should be consulted.

The Code is divided as follows:

Part I—New Installations.

Part I—Section I—Power Boilers (this section does not apply to heating boilers or boilers not built under the Code rules).

Part I—Section II—Boilers used exclusively for low pressure steam and for hot water heating and hot water supply.

Part II—Existing Installations (this part applies to boilers in service 1 yr. after the rules become effective).

Par. 379—Boilers in service 1 yr. after these Rules become effective shall be operated with a factor of safety of at least 4 by the formula. Five years after these Rules become effective, the factor of safety shall be at least 4.5.

As this boiler should be considered under paragraph 379, if the rules have not been in effect more than 5 yr., a factor of safety of 4 could be used, which would permit a maximum allowable working pressure of 127.5 lb.

If it was proper that a factor of safety of 4.5 should be used the allowable pressure would have been 113 lb. If the A. S. M. E. Rules had not been effective 1 yr. previous to the explosion, then they did not apply at all in this case.

It seems apparent, in this case, that the inspector's decision was well within the requirements of the state rules. The readers would be interested to know why the boiler failed. The original construction of longitudinal joints was triple riveted and double butt strap, but the half sheet part had a lap joint double riveted, and this joint failed, but how is not stated. It could fail by tearing the plate in the net section (between the rivet holes), by crushing the plate in front of the rivets, or by shearing the rivets.

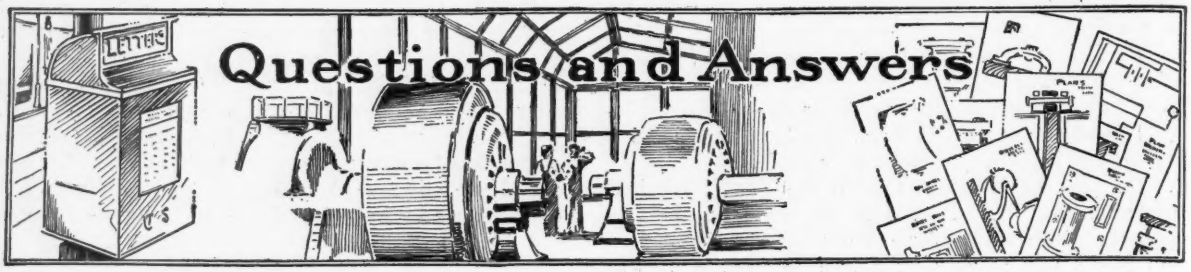
The plate may have been seriously corroded or grooved, or a lap crack may have developed. As the safety valve was reported in good order, it does not seem to be a case of over pressure. And, from all information at hand, the boiler was not allowed too much pressure for the construction. What is the answer?

We hope Mr. Tompkins will give further details, which may be of great value to our readers for their future guidance. I. B. LEAVITT.

Cutting Gage Glasses

I HAVE DISCOVERED a couple of new gage glass stunts. I use the Firma glass in my boiler and feed pump regulators and these glasses are impossible to cut with a glass cutter. I find I can break them evenly by cutting a good deep line around the outside and bringing the glass across my knee. I had to get an 8-in. glass from a 16-in. length and the cutter would not do the trick. When I put the glass in the governor, it leaked around the bottom gland nut. I had a regular rubber gasket in, so I wound a layer of candle wicking around so it came between the rubber and the valve body, leaving the rubber at the top of the nut. This makes a very tight joint. A rubber gasket and candle wicking will work when one or the other will not. STRAIGHT LINE.

U. S. CIVIL SERVICE COMMISSION announces an examination, June 15, for electrical aid (fire control). A vacancy in the Navy Yard, Brooklyn, N. Y., at $8.80 a day, and vacancies in positions requiring similar qualifications, at this or higher or lower rates of pay, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion.



Dashpot Trouble for Solution

WE HAVE a 2,000,000-gal. cross-compound condensing pumping engine equipped with Corliss valves, and running at a normal speed of 20½ r.p.m. Ordinarily, we handle about 800,000 gal. of water.

Recently the dashpot began to lag. We applied some coal oil, but that failed to remedy matters. Then we disconnected the dashpot and connecting rod and found the valve sticking. We removed the cap, poured in some oil and worked the valve gear by hand until loose. This, however, remedied our troubles but temporarily, for, after a short period of operation, the sluggish action again set in. In fact, matters became so bad that the valve began to squeak, in spite of all the oil we might inject.

We then changed oil and, while this stopped the groaning, the dashpot was unable to drop. It appears to have too much cushion, in spite of all we may be able to do. Can some of the readers of Power Plant Engineering tell me the cause of my trouble and how I can remedy it?

Also, in starting up, we have a knock in the low-pressure cylinder; this is more of a slam at the end of each stroke. Why is this? R. N. D.

Why Does the Bearing Heat?

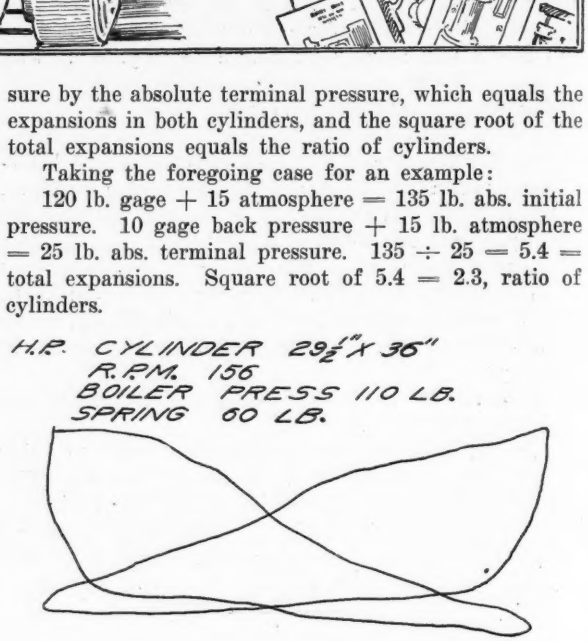
IN THE March 1 number, page 304, X. Y. Z. shows a card from the low-pressure cylinder of an Erie City engine. This card looks exactly like one I got from an engine of this description, operating under X. Y. Z.'s conditions, in a plant where I was at one time employed. The cylinder dimensions of my engine were different, however, being 29½ by 48 by 36 in., instead of 29¼ by 46 by 36 in.

I was curious to know if this was the same engine that I had at one time run. Having an idea who X. Y. Z. was and where he was located, I wrote him and, sure enough, it was the same engine in the same plant and operating under conditions that I was familiar with, and, furthermore, X. Y. Z. had made a mistake in his cylinder sizes, for in his letter he said that I was correct and that the cylinders were 29½ in. high, 48 in. low, and 36 in. stroke.

Now, for the benefit of X. Y. Z., and the other readers of Power Plant Engineering, I will say that this engine was designed to operate noncondensing, but not against any such back pressure as 10 lb. First, let us see if the cylinder ratio is correct for X. Y. Z.'s operating conditions, which are: initial pressure, 120 lb. gage, and terminal pressure, 10 lb. gage. A simple rule for finding the ratio of the area of cylinders for a compound, noncondensing engine is to divide the absolute initial pressure by the absolute terminal pressure, which equals the expansions in both cylinders, and the square root of the total expansions equals the ratio of cylinders.

Taking the foregoing case for an example:

120 lb. gage + 15 atmosphere = 135 lb. abs. initial pressure. 10 gage back pressure + 15 lb. atmosphere = 25 lb. abs. terminal pressure. 135 ÷ 25 = 5.4 = total expansions. Square root of 5.4 = 2.3, ratio of cylinders.



CARDS TAKEN FROM HIGH- AND LOW-PRESSURE CYLINDERS

The diameter of the high-pressure cylinder is 29½ in., area is 683.4 sq. in. The area of the low-pressure cylinder should be 2.3 times area of high, so 683.4 × 2.3 = 1571.8 sq. in. A cylinder having an area of 1571.8 sq. in. will have a diameter of 44⅜ in. These figures indicate that the low-pressure cylinder is too large for X. Y. Z.'s operating conditions and allows the steam to expand to less than atmospheric pressure. This is what causes the loops in the indicator cards.

Now, let us assume that X. Y. Z. can reduce his back pressure to 2 lb. gage, or 17 lb. abs. terminal pressure. Using the same formula, we have 135 ÷ 17 = 7.9. The

square root of 7.9 = 2.8, ratio of cylinders. Area of high-pressure cylinder, 683.4 sq. in., × 2.8 = 1913.5 sq. in., area of the low-pressure cylinder. 1913.5 sq. in. in area is equal to a diameter of 49⅜ in. This low-pressure cylinder compares favorably with the one in question, which is 48 in., and shows that the engine is not designed to operate against a back pressure much above atmosphere.

While in charge of this engine, I took a number of cards. Some I have are the same as the one X. Y. Z. sent in. The accompanying cards were taken from the high- and low-pressure cylinders with 110 lb. steam, 2 lb. back pressure and 30 lb. receiver pressure. Note the difference in the low-pressure card with back pressure reduced to 2 lb. At the time these cards were taken, the engine was carrying a load of 260 amp. a. c., 2300 v., 60-cycle, 3-phase, and turning 156 r.p.m. High-pressure cylinder was developing 700 hp. and low-pressure 464 hp.

The natural solution of the problem would be to reduce back pressure or increase initial pressure; but, knowing the operating conditions, as I do, neither of these changes could possibly be made.

While in this plant, I changed the exhaust piping of the engine and put a valve between the high-pressure cylinder and receiver, so that the low-pressure cylinder could be cut out, and, after removing eccentrics and side rod, I intended trying to operate the engine on high-pressure side alone, but I left before I had a chance to try this out.

Roy Winans suggested this same scheme in the April 1 issue of Power Plant Engineering, and I think that is the logical solution of the problem.

With the engine operating with no compression (and all other events taking place out of time), as shown by X. Y. Z.'s card, there is nothing to cushion the reciprocating parts, therefore, a certain amount of pounding invariably takes place. This pounding, even if slight, will, in a high-speed engine, soon develop heat in a bearing far in excess of that caused by natural friction in a bearing properly adjusted and oiled and not subject to pound.

The governor on this engine is of flywheel type and controls the cutoff on the high-pressure side only. The cutoff on the low-pressure side can be changed from ⅛ to ¾ by shifting the eccentric, but the point of cutoff remains fixed while the engine is in operation.

I hope X. Y. Z. will inform Power Plant Engineering readers what luck he has in operating this engine on the high-pressure cylinder alone.

HARRY J. BADCON.

Blowoff Pipe Problems

IT IS not considered good practice to install a steam boiler blowoff pipe as shown in the letter from S. T. J. in the May 15 issue, page 537, unless it is absolutely impossible to connect it any other way. If there has to be a nipple on the connection, why not have it on the pipe outside of the combustion chamber? It would also be advisable to use extra heavy malleable elbows instead of those of cast iron.

The pipe passing through the back wall should be free to move when expansion or contraction occurs. One good method to secure this condition is to leave the pipe loose in the brick work, or in a collar, and to wedge dry asbestos firmly between the blowoff pipe and the wall or collar; the asbestos, being flexible, will give enough to allow pipe movement and still remain fairly airtight.

It would also be well to connect a circulating pipe to the blowoff. Such a circulating pipe has been illustrated and described in former numbers of Power Plant Engineering, and its description can be found in any modern engineering text book.

The missing bricks may have been blown out when the elbow broke, or the back "kick" of the water, when blowing down, may force back the outward elbow enough to knock the bricks out of place.

C. H. gives a new idea in blowoff installations. The principal uses for a blowoff are to empty a boiler and blow out scale or dirt.

The only time a strainer should be used over a steam boiler blowoff inside the boiler is when such boiler is being cleaned out. If there is much scale in the boiler, and no screen is used at cleaning out time, the blowoff pipe is likely to become filled with scale as it is being drawn towards the back handhole. I should have the strainer removed at once. Next to the safety valve and water column, the blowoff is the most important connection around a steam boiler. JAMES E. NOBLE.

Why the Knock?

REFERRING to J. L. S.'s letter, I will state that he shows a beautiful pair of diagrams. I have but one suggestion to make, and that is that the compression on both ends of the piston is the least bit too low, for economical operation.

The knock, in my opinion, is not caused by the valve setting, but rather by some of the following causes. The clearance between the piston and cylinder head may be too small in both ends. Unequally divided compression and not enough clearance in the knocking end, together with the compression may, under certain loads, allow the piston to hit the cylinder head. The main shaft crankpin bearings or the crosshead bearing may have too much play, and under irregular loads, with the close clearance caused by the lost motion, would allow the piston to hit the cylinder head. It may be possible that the snap-rings were not made correctly, and that under certain working conditions they catch in the steam ports. I see no other cause for the knock, unless there is an unusual amount of condensate entering one end of the cylinder.

H. W. ROSE.

HAVING READ about the trouble J. L. S. has with his Corliss engine, I will state an experience I had with an old Brown.

We had the engine overhauled and a new piston put in with snap rings. This was a "rush" job. When we had been running some time, a thump came in the cylinder, and at the moment of opening of the head end valve, as described by J. L. S.

As the repair men had left in a hurry to catch a train, it was up to me to find the trouble.

The piston on the old Brown passes over the port, and to allow the steam to get by, a piece is beveled from

the edge of the follower. The piston is keyed to the crosshead and, in this case, the position of the key way was such that when the rod was keyed to the crosshead, the beveled edge of follower was thrown up to the top of the cylinder, and the full width of the follower was passing over the port.

To remedy this quickly, I marked the port position on the follower, removed and beveled it off, and my trouble was over.

I would suggest that J. L. S. note the water level in his gage glass at the time the thumping occurs. In my case, I noticed that the thumping happened when forcing the fires, or when water was slightly high.

I hope J. L. S. will let us know what his trouble was and how he remedied it. G. W. T.

Answers to Electrical Questions

THE FOLLOWING are answers to a list of questions which appeared in the Mar. 15 issue.

1. For large three-phase systems that operate at only a moderately high tension, the three-phase transformers are slightly superior to the single units in the following points: lower initial cost, smaller floor space required, simpler wiring and higher efficiency. The disadvantages of three-phase transformers are: less flexibility, more expensive stock of spares, increased liability to interruptions to service and more expensive maintenance and replacement. Due to the difficulty in insulating, very high tension three-phase transformers are seldom employed. When three units are used in delta, if one unit becomes damaged, it may be cut out of service and the two remaining transformers will carry 60 per cent of the load, operating in open delta. The question of the superiority of one class over the other is not definitely settled, as the choice and use is largely a matter of personal preference and experience on the part of the engineer.

2. All the electrical energy which is lost in a transformer, is converted into thermal energy (heat) which is dissipated to the surrounding air, the foundations and cooling agencies by conduction convection and radiation. The transformation from electric energy into thermal energy is accomplished in three distinct ways: (a) The copper or I^2R loss in which the current heats up the copper winding due to its ohmic resistance. This loss is proportional to the resistance of the windings and the square of the current. (b) The hysteresis loss, or so-called magnetic friction, the theory being that each atom of iron must reverse its direction every time the current reverses, and that in reversing, it rubs on the other atoms, thereby producing heat from the friction between atoms. The hysteresis loss is proportional to the frequency of the circuit and to the 1.6 power of the magnetic density. (c) The eddy-current loss due to each lamination acting like a closed secondary circuit and having a current induced in it by the changing current in the same manner that the voltage is induced in the secondary winding. These little circulating currents in the iron, heat it just like current from an external source would do. Were the iron solid, the resistance would be so low that the small voltage induced in the iron would cause an enormous current to flow; for this reason, the core is built of laminations which increase the ohmic resistance of the iron and minimize the eddy currents. The eddy current loss is proportional to the square of the frequency and the square of the magnetic density.

3. The effect of connecting a direct-current voltmeter across an alternating-current circuit, depends entirely on the principle of operation employed in the voltmeter. If the meter be of the D'Arsonval principle employing a moving coil and permanent magnet, then no definite indication will be noticed, the pointer staying near zero and vibrating violently in synchronism with the alternating current. If the alternating current wave be non-symmetrical, there will be a slight tendency to vibrate above or below zero. If the alternating current voltage be too high, the vibrations may be sufficient to snap off the pointer in some of the cheaper voltmeters.

If the moving iron and stationary coil principle be employed either as an inclined coil, solenoid and plunger, or attraction or repulsion coil, then a positive deflection will be obtained; but the accuracy will seldom be within 5 or 10 per cent, depending on the frequency and the design. This type not only reads low on alternating current but the scale distribution is often entirely different.

If the dynamometer or kelvin balance principle be employed, the voltmeter will read the correct, effective voltage of the alternating current circuit. While there may be a slight error, it will be only one or two-tenths of one per cent on commercial circuits, which of course is negligible.

From the foregoing, it is evident that a direct current voltmeter will seldom be damaged by connecting to an alternating current circuit; however, the converse is not true, as many alternating current voltmeters will be permanently damaged or burnt out if connected for any length of time to a direct current circuit of the same voltage.

4. When alternators are operated in parallel, the alternators, the engines and the governors should all have the same characteristics from no load to full load, to insure satisfactory operation. One great trouble with parallel operation is that the alternators will sometimes "hunt" and unless properly damped, they will finally fall out of step and shut down the plant. Therefore the governors should be quite sluggish in their action, as if a sudden load is applied and it tends to make the machines hunt, a sensitive governor will only aggravate the hunting, while a sluggish governor will allow a heavy wattless current to flow between machines and this quickly damps out the hunting and pulls the alternators into step. By this time, the governor has opened sufficiently to enable the engine to carry its increased load. If the alternators, prime movers and governors do not have the same characteristics, then the load will not divide evenly and there will be a large wattless current between machines which will cause unnecessary heating and waste of energy. Experience and experiment are the best guides in adjusting the sluggishness of the governor.

5. There is very little difference in operation between alternating-current motors on circuits of 25 to 60 cycles, of course using a correctly designed motor on the frequency and voltage for which it was designed. Below 25 cycles, the motor for a given horsepower becomes excessively large although more efficient, and it is difficult

to get a high speed with small motors. Above 60 cycles, the losses increase rapidly and together with other impractical features of high frequency has placed the upper limit for motor operation at about 60 cycles.

With the old carbon lamps, there was a distinct flicker on 25-cycle lighting circuits which was very annoying. This was due to the lamps having a negative temperature coefficient which exaggerated the flicker. With modern lamps, however, the temperature coefficient is positive and the flicker is hardly noticeable, so that lights may be operated satisfactorily on any frequency from 25 cycles up. For lighting circuits alone, however, the efficient design of transformers has placed commercial lighting circuits at about 60 cycles.

Until recent years, rotary converters could not be operated satisfactorily on circuits much above 25 cycles. Present day rotaries, however, when correctly designed and damped, will give equally good performance on 25 or 60-cycle circuits.

There are few commercial circuits of above 60 cycles or below 25 cycles in the United States and even these are rapidly being changed to 25 or 60 cycles, due to the difficulty in getting apparatus to operate on odd frequencies. In foreign countries, extensive use is made of 40- and 50-cycle circuits for both light and power.

6. There are three ways of starting a rotary converter: (a) If direct-current is available, the converter is started by energizing the direct-current end, bringing up to speed as a direct-current shunt motor and synchronizing. (b) Many converters employ a small motor connected to the converter shaft to bring the converter up to speed without load when it is synchronized and then loaded on the direct-current side. This motor is generally a small induction motor with two less poles than the rotary converter in order that the converter may be run slightly above synchronous speed which would be impossible if the motor had a number of poles equal to the rotary. (c) The converter may be started by applying about half alternating-current voltage and letting it come up to speed by induction (no field on) and then applying full voltage and field. In this case, the field coils should be connected to a field break-up switch which completely insulates each coil from the others. This is necessary, as there is a high voltage induced in each coil and if the field coils are left in series, the voltage may build up sufficiently to puncture the insulation. With this method, the direct-current polarity cannot be determined beforehand, so if after energizing the field, the voltmeter shows reversed polarity, it is necessary to "slip a pole." This is often done by opening the field switch an instant and immediately reclosing it, and continuing this opening and closing until the armature is caught one pole back when the polarity will be correct and the direct-current load may be applied.

7. The difference between the motors for a high-speed and slow-speed elevator is not so great as the methods of application and gearing. On direct-current practically all elevators use a heavily compounded motor (generally an interpole) and start as a series motor with a strong series field, gradually cutting out the series field (by short-circuiting turns) and building up on the shunt field until at full speed, the motor operates as a shunt motor. On alternating-current, the best motor is the polyphase induction motor with a form wound rotor, terminating in collector rings to which is connected an adjustable resistor. This gives a maximum starting torque with a minimum current. The induction motor which starts as a repulsion motor has also been successfully employed in elevator service. All elevator motors are especially designed to withstand the severe shocks of repeated starting and stopping under load and are frequently installed slightly over size to lessen the severe service imposed on them.

Regarding the elevators, there are two general classifications: those with winding drums and those with traction sheaves. The winding drums are generally used with slow-speed elevators having about a maximum travel of 100 ft. per min., while the elevators with traction sheaves may run from 200 to 700 ft. per min. and the length of travel is only limited by the height of the building.

8. This question is very indefinite, as the voltages of a plating dynamo and a lighting circuit are so far apart that it is hard to tell what is meant by the use of a plating dynamo on a lighting circuit. If the plating dynamo is connected to a motor which is run from the lighting circuit, and the load is not heavy enough to cause unusual voltage variation at the lamps, then it will give good service. If of the commutator type and it is desired to light lamps, undoubtedly it will have to be rewound and supplied with a new commutator in order to give good service, as the voltage generated is generally only 5 to 10 volts, for which it would be difficult to obtain efficient large lamps, and the commutator would have to have more bars to prevent flashing over. This question cannot be answered satisfactorily unless the type of machine be known and the service stated for which the dynamo is to be remodeled.

9. In general, synchronous motors are used to best advantage where they have a steady load to carry, where they need not start under load, where the starting and stopping is infrequent and where it is necessary to correct a low power factor caused by a load of induction motors. Ammonia refrigerator pumps, air compressors, group drivers and motor generators present applications for synchronous motors, while practically all other industrial operations may be served to good advantage by induction motors, as they can be obtained with a great variety of characteristics in the line of starting torques, speeds, variable or constant and full load torques.

Induction motors inherently have a low power factor, so great care should be used in their selection in order to obtain a motor which is not too large or too small for the work which it must perform. E. REINMAN.

Refrigeration Questions Answered

AS REQUESTED by R. G. S., in the March 15 issue, I submit the following answers to his questions.

In the compression system of refrigeration, either the ammonia gas is used as the refrigerant direct to the cooling rooms or a medium is used from which the ammonia gas extracts the heat as it passes through coils enclosed in a steel tank into which the ammonia gas enters through an expansion valve and returns to the compressor, which pumps it to the condenser, from which it again goes to the expansion valve.

The absorption system is composed of a steel shell called the generator, in which a weak solution of ammonia is maintained that covers a set of steam coils which boils out the ammonia gas, after which it passes through the analyzer to the exchanger on its way to the rectifier, after which it goes to the condenser, then to the receiver, from which it is led to the different expansion valves, where the brine refrigerant is cooled as it passes through the coils enclosed in a cylindrical tank. The expanded gas, under a few pounds pressure, passes to the absorber, where it is absorbed by a weaker solution piped from the bottom of the generator to the absorber, where the contents becomes a strong solution, from whence it is pumped through the exchanger on its way to the generator.

2. The double-pipe ammonia condenser is made up of a bank of pipes with suitable joints, with the high-pressure ammonia gas flowing in at the top of the bank through the inner pipes and returning at the bottom, the condensing water flowing counterwise entering the bottom of the bank passing through the outside pipes returning from the top of the condenser; hence the coldest water meets the coolest or liquefied gas at the bottom of the condenser. Bends are removed at the ends to use a tube brush to clean the mud and scale from the inner or water pipes without interfering with the ammonia joints.

The atmospheric condenser is made up of a bank of single pipes with bends joining them at the ends. A corrugated water trough runs lengthwise over the top of the bank into which cold water flows, trickling down over the coils. The ammonia gas enters at the bottom and by means of intermediate or liquid pipes connecting with the main pipes of the condenser, the liquefied gas is returned to the receiver as fast as it forms, thus preventing its descent to the lower and warmer pipes of the coil with its consequent re-expansion, which would materially increase the pressure.

3. The stuffing-box of an ammonia compressor of the vertical type is usually packed with lead or babbit metal rings cut with a bevel, so that when they are subjected to pressure, every alternate one hugs the piston-rod, while the others are pressed tightly against the inner surface of the stuffing-box, thus forming a tight, yet smooth, working packing.

The packing should be driven tightly home, piece by piece, and then the gland should be screwed on only hand-tight, so as to allow the packing room to expand and fill the spaces without undue pressure. A ¼-in. pipe is tapped through the stuffing-box to the perforated ring leading to a hand pump and a liberal supply of oil should be forced into the stuffing-box at intervals of an hour or so.

4. Ammonia screwed pipe joints are made up satisfactorily with a paste made of litharge and glycerine, but where bolted flange joints are used a rubber ring or lead gasket is inserted between the flanges; some flange joints have a thimble and two rubber rings inserted between them.

5. The analyzer is used with an absorption machine and consists of a steel shell enclosing a number of perforated baffle plates through which the ammonia gas rises on leaving the generator, straining the moisture from the gas and returning it back to the generator. The strong solution is pumped from the absorber through the analyzer before going to the generator.

6. The direct expansion system consists of expanding the ammonia gas in the coils of the cooling rooms or other places where the refrigeration is required. With the indirect expansion system brine is used as the refrigerant and is cooled by ammonia gas as it passes through coils in the cooler located in the engine room. The greatest drawback to using ammonia directly is the liability of ammonia to leak through the fittings, joints, etc.

7. The usual method of determining when an ammonia shipping drum is empty is when it begins to frost on the bottom at the outlet end, but, if the weight of the empty drum is known, a safer method would be to weigh the drum both before and after the operation.

8. Charging in with anhydrous ammonia is usually done in the absorption system through a convenient connection leading to the cooler after the expansion valve has been closed down long enough to bring the back-pressure down to about 2 lb., and the aqua-ammonia is pumped from the drum through the exchanger, after which it goes through the analyzer and then into the generator. Charging in with the direct expansion system, after the expansion valve is closed and the back-pressure down to a couple of pounds, the drum is connected at a convenient point between the compressor and expansion coils.

9. A brine tank is used for the returning brine and is a suction tank for the brine pump. A brine cooler is a tank for cooling the brine by the employment of ammonia gas.

10. When the back-pressure gage drops to below zero the system is not doing any useful work, but, on the contrary, is often doing much harm by drawing the system full of air from the pressure of the atmosphere through the valve stems and stuffing-boxes.

JAMES G. SHERIDAN.

Massachusetts First-Class Firemen's Questions and Answers

FOLLOWING are some questions recently asked:

If you shut the stop valve on a low-pressure gravity return heating system, and the water drops down in the gage glass, what is the trouble?

A. The check valve is leaking on the return line and the water, due to pressure in the boiler, is being forced up the system.

2. What is the cause of one radiator being cold at the end of a line?

A. Probably there is air in the radiator; see if the air valve is in order.

3. Where is the back pressure valve used?

A. This valve is placed on a pipe leading from the steam heating system to the atmosphere, and acts as a safety valve to the heating system.

4. Where do the returns from a gravity heating system enter the boiler?

A. The returns usually enter the blowoff pipe, which is connected to the low point of a boiler.

5. With 100 lb. boiler pressure and 5 lb. in the heating system, how do you get the condensation back into the boiler?

A. In some plants, the returns come back by gravity into a receiver on a feed pump, which pumps the water into the boiler; while in most plants there is a vacuum pump that takes the condensation from the system and discharges it into a receiver on the feed pump, which pumps the water into the boiler.

6. Is there any boiler without a feed pipe?

A. In the low-pressure gravity return heating boiler the feed is in through the blowoff pipe and is not considered as a feed pipe.

7. What is the object of an air valve?

A. An air valve is placed on a radiator or heating coil to let the air escape, and when the air is all out, the heat from the steam expands a part of the valve and the valve closes.

8. What do you understand by a safety valve?

A. This is an apparatus placed on the steam space of a boiler to relieve the boiler of over-pressure.

9. If you are feeding your boiler with traps, will the trap work if set only 1 in. above the boiler?

A. The trap must be set high enough so that the weight of water will more than counterbalance the difference of pressure in the boiler and trap.

10. Is it necessary to have two traps in feeding a boiler?

A. When the condensate comes back into a trap, it is discharged into the return trap on top of the boiler.

11. Why are hollow stay bolts used in the Heine?

A. It gives a good way to blow the tubes and also allows a greater pitch.

12. Where are the braces in a Heine boiler?

A. Near each end of the steam drum the plate is cut out for the throat opening for the connection of the water leg. To allow for the metal cut out, forged steel stays are riveted at each side of the opening.

13. How is the dry sheet protected on the flush front boiler?

A. The bricks are built out under the shell more.

14. How is it protected in an overhanging front boiler?

A. As this projects beyond the front wall, there is no danger, even if the bricks do fall down.

15. If a horizontal return tubular boiler is on the ground, how can you tell which is the front end?

A. By feed connection, water column and blowoff.

16. Is the dry sheet a separate part of a boiler?

A. In the real flush front type it is, while in the overhanging type, it is the extension of the boiler shell.

17. How does the smoke go through the horizontal return tubular boiler?

A. Under the boiler to the rear, back through the tubes to the smoke box, up the flue to the chimney.

18. How and why are the heads put in a horizontal return tubular boiler?

A. The rear head is flanged in so it can be calked from the outside; if it flanged out, the flange and rivet would burn. The front head on the flush front type is flanged in same as the back. Front head of the overhanging type is flanged out so that it may be calked from the outside.

19. Where do you feed a horizontal return tubular boiler?

A. Through front head. The pipe extends 3/5 the length of the boiler and crosses halfway over with an elbow looking down.

20. How often do you blow down a boiler?

A. A little every day. The main thing is to keep the blowoff free of scale and sediment.

21. How are the heads braced on a h.r.t. boiler?

A. Below the tubes there are through braces; above the tubes, either through-and-through or diagonal braces are used.

22. What is the object of a bridge wall?

A. It forms a back to the grate; also deflects heat toward the boiler.

23. Explain the difference between a blister and a bag.

A. A blister is a separation of the shell, while a bag is where the whole shell at one point is dropped down. Blister is caused by the plates not being of the same temperature when rolled, and a bag is caused by a foreign element, such as oil or scale, settling on the plate and, as the water cannot conduct the heat away, the plate overheats and is forced down. This is very serious and should be watched.

24. What is the difference between a hard and soft patch?

A. In a hard patch the plate is cut out and a patch put on the inside with rivets. Soft patch is put on the outside without cutting the plate.

25. What is the difference between the Manning and a common vertical boiler?

A. The Manning boiler is not the same size all the way down, due to the ogee ring. The vertical has a straight shell.

26. Where are the handholes on a Manning boiler?

A. Opposite each tube aisle at bottom tube sheet, over doors, at mud ring, at fusible plug, and where feed pipe enters; also one opposite.

27. Where does the feed water enter the Manning?

A. Up in the barrel. This holds a more solid body of water on the crown sheet; also, if water enters the water leg, the air will attack the stay bolts and keep the sediment stirred up and result in a greater deposit on the crown sheet.

28. What is the purpose of the ogee ring?

A. The heat going up through the tubes will expand them quicker than the shell would expand and result in bulged heads or leaky tubes, but by using the ogee ring this takes care of the expansion. It also gives an enlarged fire box.

29. Why is the feed pipe on the Manning boiler held in a bracket on the other end?

A. This pipe is held from vibrating by basting the outer end in a bracket. W. N. L.

Storage Battery Elements

OF WHAT does the grid lead used in storage batteries consist? Also the litharge and red lead? W. H. C.

A. The grid lead referred to is practically nothing more than metallic lead designated chemically by the symbol Pb.

Litharge is artificially prepared lead oxide PbO formed by heating melted lead in a current of air while red lead, or minimum, Pb_3O_4 is obtained by gently heating lead oxide in air, thus causing it to take up oxygen.

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Profiteering

This poor word has been used, of late, as a goat. When a man gets cornered for an explanation of high prices, high wages, high taxes, high government expenditures, he drags in "profiteering" as the excuse. Maybe he is right—at any rate, part of the time; but surely everybody is not profiteering. Ministers, teachers, postal employes, even engineers, are certainly not amassing fortunes at the expense of their fellow men. What lays a man open to be rightly called a profiteer?

Profit—excess of value received over cost. Recompense for service rendered. That doesn't carry any threat of prison stripes or public condemnation. If a man renders a service to the world or to a part of it, by making, transporting or distributing something that people want, he is of benefit to them and is entitled to compensation—or profit—proportional to the service. When does he become a profiteer? And can he be profiteer when dealing in non-essential luxuries?

That brings up the question, can a luxury be essential? Which is another chance for difference of opinion and of standards. But we will all probably admit that something beyond food, clothing and shelter merely sufficient to prevent starvation and suffering from cold and storm are essential to a modern America. Also we will admit that diamonds, furs, limousines and venison steaks cannot be classed as essentials to anybody's comfort, however commonplace they may be in the lives of some people.

If a maker of fur coats and high priced automobiles or a dealer in rare gems charges high prices, it means little, apparently, in the lives of those of us concerned with work-a-day matters. But if dealers in sugar and potatoes, or makers of ready-to-wear clothing abstract an excessive profit, that is our intimate business.

And yet, these things have perhaps a closer connection than we realize. Look at yourself, your neighbor, your friend's daughter. Are you and they buying the serviceable, essential things in food, clothing, amusements? And putting the remainder of income into conservative investments, which are now yielding nearly double the income that they did before the war, and probably much more than they will 10 yr. hence? Or are high wages leading to silk shirts, cobweb stockings, fancy shoes, frequent movie shows, expensive dinners and other costly habits? It is a personal question for every man to discuss with himself and his family.

Expensive luxuries always carry a high profit charge, as well as a high cost charge. If we insist on buying the expensive things, we are adding to the demand for them. They will be furnished, for the makers can and will pay any wages necessary to get workers, thus drawing workers away from the making of the lower-priced essentials. This, in turn, will reduce the supply and increase the cost of those essentials, thus adding to the troubles of those to whom luxuries are an impossibility. Whether we will or not, we cannot help affecting the other man's problems.

Just for instance, if everybody started today to purchase nothing but inexpensive goods of good quality, houses, cars, cotton shirts, plain clothing, wholesome food, and to renounce unnecessary service of waiters, salesmen, hat boys, doormen, chauffeurs, maids and

lackeys, some business men would have a lot of revising to do in a hurry to save their establishments from ruin, but there would be plenty of workers available to make the things we really need and to raise the food we must have.

If we kick about the man who takes an excessive profit, yet buy his goods, we are assisting him to keep on.

Any man who is working at an essential industry, to furnish shirts, socks, suits, bread and houses such as you and I and John Smith need for comfort—not show or vanity—and who does not return a full, honest day's productive work for the wages he gets is adding to the cost of those essentials. Isn't he in the same class as the dealer who tacks on an extra profit because the buying public will stand it rather than go without? He has the same argument to justify him, "If people want the stuff, let 'em pay for it." And they do. But maybe neither one is either right or justified. And there are some signs that the buying public which thinks, and has a fixed income, so that it cannot pass on the high costs—you and I and other engineers and John Smith—is getting tired. And that John and you and I are about ready to make a serious resolve to wear our old clothes (not buy new overalls), to give up all extravagances, even moderate ones, to get back to plain living, hard thinking, an earnest effort to pull our country out of its predicament. And to do our durndest to let the profiteer of high or low degree find out where he really belongs in this world—to help him rapidly into the ash dump.

A Week Without Accidents

How many times during a year can you say on Saturday night, "Not a single accident has happened in our plant this week"? We venture to say, very few. Yet why should this be? Are accidents necessary to power development?

In a one-man plant, the chances for accident are considerably less than where two men are employed and the chances for accident increase rapidly as the number of workers increase. For this reason, the larger the plant the greater the need for safety devices, organization and shop safety rules. An analysis of the great majority of accidents will prove them to be the results of human frailties; moments of relaxation, lack of judgment as to strength of materials or conditions, ignorance of plant arrangement and duties of fellow workmen and their peculiarities are among the important causes of accidents. These causes can be almost wholly eliminated if the idea of safety is uppermost in the mind. Recognizing this fact the National Safety Council has planned a No Accident Week among the public utilities of the states of New York and Pennsylvania, a notice of which is printed on another page of this issue.

Without question, much can be done towards reducing accidents by a drive of this sort when every condition which exists about the plant will be studied carefully for features of danger and a method of preventing accidents worked out.

Being thoroughly in accord with such movements, Power Plant Engineering has from time to time published articles giving safety rules and directions for protecting workmen against accidents with various types of machinery, and at the present time a series of articles along these lines is being run which works in well with the plans for the No Accident Week.

Although an organized effort is being made only in New York and Pennsylvania, every plant in the country should voluntarily celebrate this week by special efforts to prevent accidents. One whole week without an accident in a power plant in the entire nation would be an accomplishment well worth great effort and capital investment.

Proposed Remedies for Labor Shortage

PRACTICAL measures to relieve the present labor shortage were proposed by The National Immigration Conference, held on April 7, in New York City. This gathering included leaders in finance, industry and agriculture, together with labor men and representatives of foreign born groups in America, and was called by The Inter-racial Council, 120 Broadway.

The common interest which drew these varied elements together is the need of greater production, more stable labor conditions and a better understanding between the different races living in America. In other words, better team work is essential today. Americans and immigrants should learn to pull together for the benefit of all.

Among the measures proposed were greater protection for the immigrant against fraud, extortion and violence. A Federal Assimilation Bureau should be established to look after the welfare of the immigrant, help him learn our language and place him where he can work to the best advantage of himself and the nation. Standards for citizenship should be high, but useless hindrances and red tape should be done away with. An advanced immigration policy was advocated as a remedy for the present labor shortage, including the selection of industrious and thrifty men and women of good character, and their distribution to the points where they can do the work for which they are fitted. As an immigrant may be of great value to the country as an unskilled laborer, regardless of his inability to read, it was urged that the present literacy test be eliminated and this would open the gates to unskilled workers in agriculture and industry, construction, railroads and domestic service, where there is a great need for help at this time. Our present labor shortage is estimated at between 4,000,000 and 5,000,000, and this would be relieved by a policy of admitting immigrants without book learning, but of good character, sound body and mind and the Old World habits of frugality and industry.

U. S. CIVIL SERVICE COMMISSION announces an examination, June 22, for acetylene welder, for both men and women, to fill a vacancy in the Bureau of Mines, Department of the Interior, Washington, D. C., at $1500 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month. Competitors will be rated on physical ability, training and experience. Apply for Form 1800.

Improved Fan Engine or Damper Regulator

FRICTION in the pilot valve, caused by lack of lubrication of the pilot valve stem is the most common cause of sluggish operation of hydraulic damper regulators. Where no means of lubricating the stem of the pilot valve is employed, friction soon develops, due to corrosion. This results in destroying the sensitiveness of the regulator to respond to slight changes in pressure, allowing the motor to travel past the point where it should have stopped, resulting in a wide range of furnace temperatures and decreased boiler efficiency.

This difficulty has led to the development of a novel means for lubricating the pilot valve stem. This improvement consists in supplying guide bearings for the stem between the admission and exhaust ports, and providing force feed lubrication to these bearings to lubricate the stem, thus reducing friction and preventing corrosion.

The operation of the pilot valve may be understood

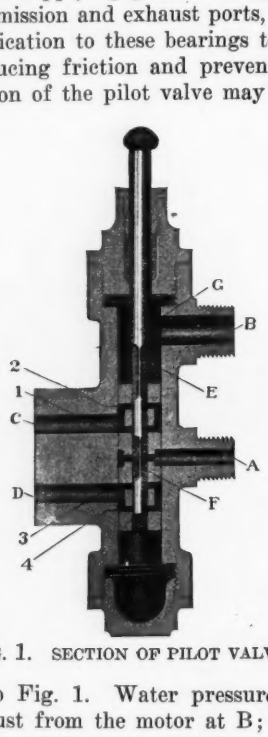

FIG. 1. SECTION OF PILOT VALVE

by referring to Fig. 1. Water pressure is connected at A, the exhaust from the motor at B; D is the port leading to the top of the motor cylinder; and C the port leading to the bottom of the motor cylinder. The stem G has flat portions, E and F, for the admission and exhaust of water pressure.

The stem is shown in a neutral position. With an increase in steam pressure, the stem is raised, opening ports 1 and admitting water pressure to the bottom of the motor cylinder. At the same time, ports 4 are opened, allowing any water in the top of the cylinder to escape through a cored passage in the side of the valve body and enter exhaust connection B. This forces the motor piston upward and closes the damper.

With a drop in steam pressure, the stem of the pilot valve is forced downward, closing port 1 and opening port 3, allowing the water pressure to enter the top of the motor and, at the same time, opening ports 2, allowing the pressure in the bottom of the cylinder to escape to the exhaust connection B.

Referring to Fig. 2, in the arrangement of this valve, a forced lubrication takes place, as it will be noted that, when the stem G is raised, guide bearing 5 is surrounded by pressure, while guide bearing 6 is open to atmosphere; in this way a small amount of water will leak past the cylindrical portion, 7, of the stem and enter the oil receptacle, 8, through port 9 and settle by gravitation to the bottom of the receptacle. At the same time, a small amount of oil will be forced through port 10, lubricating the cylindrical portion, 11, of the valve stem.

When the stem is lowered, the bottom bearing, 6, is subject to pressure and the top bearing, 5, is open to atmosphere, allowing a slow leak of water to enter the receptacle through port 10. Oil is thus fed to the cylindrical portion, 7, of the valve stem, G, and, in this way, alternately lubricates the fitted portions, 7 and 11, of the valve stem. The ends of the cylindrical portions, 7 and 11, enter the guide bushing when subject to maximum travel in either direction, and, therefore, supply lubricant to the entire length of the bearing.

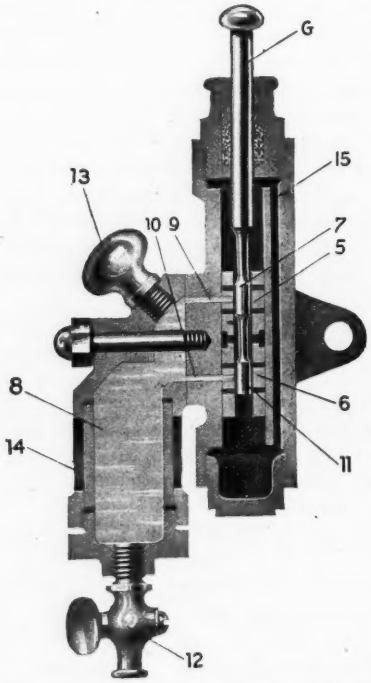

FIG. 2. SHOWING METHOD OF LUBRICATING VALVE STEM

A pet cock, 12, is provided in the bottom of the receptacle for drawing away the water before filling with oil, which is supplied at 13. A sight glass, 14, is provided for determining the height of the oil in receptacle 8.

No Accident Week

THE PUBLIC utility interests of the states of New York and Pennsylvania have set aside the second week of this June for the observance of an Accident Prevention Drive. This week will be called "No Accident Week" and will have the hearty backing of public utility interests and various organizations such as the Empire State Gas & Electric Association, who will give it publicity in their publication.

Several hundreds of public utilities last fall concerted a safety effort during the week of Nov. 16-22, calling

it "Safety Week," and accomplished the remarkable result of but one-fifth the days lost time that normally obtained at that period of the year. In addition, it was found that "Safety Week" had such a marked influence on subsequent weeks that the need was felt all the more for a similar effort in 1920.

Accordingly, June was chosen so as to anticipate the tendency for a higher frequency rate of serious accidents, a condition which is peculiar to public utilities and naturally so since construction work, etc., is under full swing during the good spring and summer weather.

The committee of prominent officials of public utilities has been actively engaged in developing material that will assure the success of this week for any company or committee that undertakes its observance. This material will consist of a very appealing poster in colors, which is to be used about a week ahead of "No Accident Week," to advertise the idea. Then during the week there will be six bulletins for daily changes. These bulletins will be in black and white and of a decided variety from the caricature style to that which makes a direct emotional appeal to the human side.

There will also be a very attractive button which will embody the National Safety Council's established emblem of the white cross on the green background, encircled by the slogan "Universal Safety."

The observance of the week is going to be carried on enthusiastically on the following properties: Buffalo General Electric Co., Harrisburg Light & Power Co., Niagara, Lockport & Ontario Power Co., Northern New York Utilities, Inc., Northwestern Electric Service Co., Rochester Gas & Electric Corp., Western New York Utilities Co. and The Wilkes-Barre Co.

News Notes

MONTREAL, Quebec, has been chosen for the coming meeting of the Associated Manufacturers of Water-Purifying Equipment, to be held in conjunction with the Annual Convention of the American Water Works Association, during the week of June 20. A full representation is expected and plans are under way to make this the most constructive and interesting meeting yet held.

Adequate and efficient water purification is now recognized as a vital factor in the operation of nearly all industries. There has accordingly been a rapid expansion of the manufacturers of purification equipment. The feeling that they can better serve the consumer and themselves by an exchange of ideas has prompted these manufacturers to maintain this organization of live wire representatives.

One important aim of the Association is to secure uniformity of contracts and sizes of filters. To expedite this purpose, committees on standardization of contracts and filter sizes have been at work for some time and full reports, together with tentative forms and schedules, will be submitted at the coming meeting.

Under the able direction of the President, Arthur M. Crane, the organization is successfully following out the purposes for which it was formed. The name, "Associated Manufacturers of Water-Purifying Equipment," has been registered in the United States Patent Office, and, through the efforts of the Membership and Publicity Committees, a substantial increase in members has been realized during the past few months.

AT THE May 11 meeting of the Engineering Advertisers' Association, William Bethke, secretary and editorial director of the La Salle Extension University, and president of the Executives' Club of Chicago, addressed the association on the subject, "What makes advertising effective for the engineering advertiser?" Mr. Bethke emphasized the importance of making engineering advertising stand on its own merits by giving positive and dependable data regarding the product or service advertised. "Much advertising today," said he, "has nine strong points and one weak point, and it fails on its weak point. Engineering advertising cannot afford to have a weak point." Mr. Bethke offered specific instances to illustrate his argument, and his address was cordially received.

At this meeting, also, W. Frank McClure gave a brief history of the National Advertising Commission, of which he is chairman, and explained its functions. The National Advertising Commission, Mr. McClure stated, was organized about 10 yr. ago, and, through its various departmentals, has been a leading factor in bringing advertising up to its present high standard of dependability and efficiency.

THE NOMINATION of Dr. Frederick G. Cottrell for director of the Bureau of Mines, Department of the Interior, has been sent to the Senate by President Wilson, to take the place of Dr. Van. H. Manning, resigned. Dr. Cottrell was the assistant director of the Bureau under Dr. Manning.

THE TWO 60-cycle turbine-generators which will be installed in the new Hell Gate station of the United Electric Light & Power Co., of New York, will be of the tandem-compound type, each rated at 43,750 kv.a. at 80 per cent power factor, or 35,000 kw. They will be designed to carry peak loads of 40,000 kw. for short periods. These units, which will be built by the Westinghouse Electric & Manufacturing Co., will be similar to the 60-cycle units installed in the Northwest station of the Commonwealth Edison Co., with the exception that the newer units will have a rating of 43,750 kv.a., as compared with 35,300 kv.a. for the Chicago units. The generators will be designed for 13,200 v. and the units will operate at 1200 r.p.m.

The turbines will be designed to operate at 220 lb. steam pressure, 200 deg. F. superheat and 29 in. vacuum. They will have reaction blading throughout. The high-pressure element of this type of machine is single-flow and the low-pressure element is double-flow.

The Engineering Advertisers' Association has made application, through Mr. McClure, for representation on the National Advertising Commission.

Trade News

WALTER N. POLAKOV & Co., Inc., specialists in mastering power production, tests, reports, record and cost, supervision of purchase, and consultations on management, announce the new location of the office at 33 W. 42d St., New York City.

SPRAY ENGINEERING Co., of Boston, Mass., reports unusual activity in the sale of cooling ponds, the month of April having been the largest in the history of the company. Of the 800 or more Spraco cooling systems scattered over 41 states and 14 foreign countries, these additional ones have been installed since Jan. 1, 1920: Electric Transmission Co. of Virginia, Pocket, Va., 10,000 g.p.m.; National Enamelling & Stamping Co., Granite City, Ill., 10,000 g.p.m.; Wichita Falls Electric Co., Wichita Falls, Texas, 10,400 g.p.m.; Marland Refining Co., Ponca City, Okla., 11,500 g.p.m.; Pittsburgh Plate Glass Co., Kokomo, Ind., 15,000 g.p.m.; American Gas & Electric Co., Scranton, Pa., 16,000 g.p.m.; General Motors Co., Buick Plant, Flint, Mich., 16,800 g.p.m.; Goodyear Tire & Rubber Co., Akron, Ohio, 18,050 g.p.m.; Cosden & Co., Tulsa, Okla., 26,000 g.p.m.; Dallas Power & Light Co., Dallas, Texas, 36,200 g.p.m. The list of industries represented is so varied that this bid for higher efficiency presages an unusually active business year.

CENTRIFUGAL pumps for sugar house service are described in Bulletin S, issued by the De Laval Steam Turbine Co., of Trenton, N. J. Centrifugal pumps are recommended for sugar house work because of their simplicity, reliability, high economy, wide range of capacity and small space requirements. There are no valves, and but two simple packings. The only parts subject to wear by rubbing are the bearings, the lubrication of which is automatic. Little attention is required, and inspection is easily made. De Laval centrifugal pumps are characterized by horizontally split casings, by the fact that all parts are made to limit gages and are interchangeable, by comprehensive guarantees covering capacity, efficiency, and the relation between delivery and pressure, and by the fact that each pump is fully tested before leaving the shops. The present bulletin describes centrifugal pumps for handling raw juice, limed juice, soda, syrup, boiler feed water and injection water, and for maceration and hydraulic pressure service, etc. Motor and turbine-driven pumps, both single-stage and multi-stage, are illustrated and described.

THE WESTINGHOUSE ELECTRIC INTERNATIONAL Co. is issuing a monthly magazine, whose columns will be devoted to the electrical industries throughout the world. This publication, which is printed in English, contains engineering, semi-technical, merchandising and popular articles, together with international electrical news.

One of the features of this magazine is the pictorial section, which illustrates some of the great engineering feats of this country. The column, "I Want to Know," is incorporated in order that technical and general questions may be asked and answered. The publication is for foreign distribution. Beginning with the July issue, portions of the magazines will be printed in Spanish and Portuguese.

THE BENJAMIN ELECTRIC MFG. Co., Chicago, has issued Catalog 22, comprising a complete listing, descriptions and illustrations of Benjamin electrical specialties.

In addition to the catalog data, there is a section devoted to useful information upon illumination requirements and also a chapter setting forth simple rules for laying out lighting plans for the attainment of correct industrial lighting.

A numerical index gives full details covering catalog numbers, list prices, package quantities, weights and discount schedules.

For convenience, the material listed in this catalog is grouped into schedules, with mechanical separators, tabbed for quick reference.

The following schedules are listed: Schedule 1, Wireless Clusters and Plug Clusters; Schedule 2, Industrial Lighting Fixtures and Reflectors; Schedule 3, Wiring Devices; Schedule 3H, Attachment Plugs; Schedule 4, Special Fixtures and Fittings; Schedule 6, Industrial Signals; Schedule 8, Panel Boards.

EDW. R. LADEW Co., Inc., Glen Cove, N. Y., has published a new booklet, entitled "Ladew Leathers," covering the line of leather goods made by this firm. Of particular interest are the sections devoted to leather packing and V-belt.

THE FAIRBANKS Co. has recently issued a 256-page catalog illustrating and describing its complete line of power transmission appliances and elevating and conveying machinery. In addition, the catalog contains full data as to dimensions, capacities, etc., making it a useful handbook for the man who designs or installs mechanical equipment of this nature. The book, which is attractively bound in dark green cloth, will be sent on request to executives, engineers, master mechanics, millwrights, and those concerned in procuring material described.

"THE AERIAL RAILWAY OF INDUSTRY" is the title of the latest bulletin of the Shepard Electrical Crane & Hoist Co., Montour Falls, N. Y. Besides describing this firm's line of monorail hoists and trolleys, the bulletin gives plans of two typical installations of such equipment, together with illustrations of the machines employed.

LEAFLETS from Steere Engineering Co., Detroit, Mich., state briefly the main features of the company's cooling coils, electrically welded steel pipe and fittings, welded steel piping, valves, Intensive Scrubber (for ammonia from coal gas, for gasoline from natural gas, for soluble products from any gas), and Doherty washer-coolers.

A NEW 56-page catalog, from Howard Iron Works, Buffalo, N. Y., lists the Burdict bolt and nut machinery, with the more recent additions to Howard products and additional material pertaining to the range of the company's activities, from a small pinion to a ponderous steel mill table.

CATALOG No. 14, of The Borden Co., Warren, Ohio, contains 40 pages of description, illustrations and price lists of Beaver die stocks, pipe cutters and various other threading and cutting tools.

THE LATEST publication of the Lagonda Mfg. Co. is an eight-page bulletin with cover, descriptive of Lagonda boiler tube cutters. The bulletin goes into the subject of cutting out boiler tubes and illustrating Lagonda tube cutters as used in different types of boilers and showing in detail how the cutter works.